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November 28 & 29, 1978
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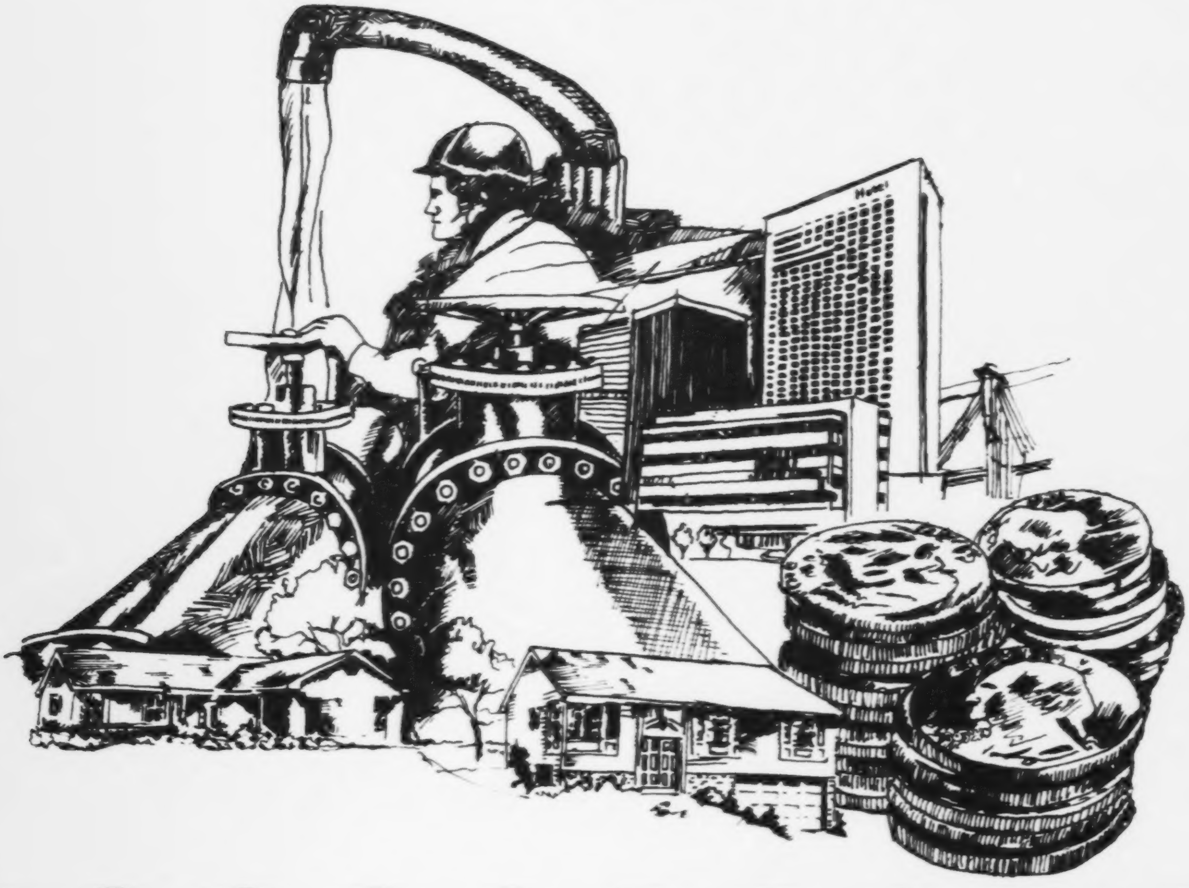

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This document is a compilation of 28 papers presented at the National Conference on Water Conservation and Municipal Wastewater Flow Reduction, sponsored by the U.S. Environmental Protection Agency on November 28 and 29, 1978.

The papers are divided into six major topic areas: Federal legislative background; regulation of the water resource; water conservation technology; education and public participation; water resource management. Individual papers range from economic analyses, to planning considerations, to discussions of household water conservation devices. Also included is the text of President Carter's 1978 Water Policy Message and an analysis of National Conference attendees by profession.

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Foreword

As our population increases, as our per capita consumption of water continues to grow, and as our standards for water quality rise, costs for treating the resultant wastewater burgeon. One partial resolution of the problem of rapidly rising costs lies in greater attention to water conservation and water use management. Through conservation, costs for energy, materials, land and labor can be minimized.

During the National Conference on Water Conservation and Municipal Wastewater Flow Reduction held in Chicago on November 28 and 29, 1978, more than 500 persons, representing a wide variety of experiences and viewpoints, met to discuss their common concerns about water and wastewater management and how these concerns relate to conservation. The conference focused mainly upon municipal and household conservation measures, with speakers presenting papers ranging from the theoretical to the highly practical. Topics during the two-day meeting varied from the analysis of rate structures that encourage conservation, to discussions of household water flow control devices.

Participants represented all levels of government, citizen action and environmental groups, representatives of the engineering professions, researchers based largely in universities, builders of water-handling equipment, planners and others. Many participants expressed satisfaction that for the first time, they had had the opportunity for extended face-to-face communication with persons with widely different perspectives about what the water conservation problems are, and how they might be resolved.

This Proceedings volume provides nearly all of the papers presented for the use of a broader audience interested in one or more aspects of water and wastewater management in the United States today.

Abstract

This document is a compilation of 28 papers presented at the National Conference on Water Conservation and Municipal Wastewater Flow Reduction, sponsored by the U.S. Environmental Protection Agency on November 28 and 29, 1978.

The papers are divided into six major topic areas: Federal legislative background; regulation of the water resource; water conservation technology; education and public participation; water and wastewater management issues; and case studies of water resource management. Individual papers range from economic analyses, to planning considerations, to discussions of household water conservation devices. Also included is the text of President Carter's 1978 Water Policy Message and an analysis of National Conference attendees by profession.

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From the inception of the idea for the conference, numerous persons outside the Federal service provided ideas and material assistance. An informal group of advisors who deserve credit for the success of the conference included Kenneth Brewster and Neil Fulton of the Division of Water Resources, Illinois Department of Transportation; Richard W. Church, Executive Director, Plumbing Manufacturers Institute; David M. Farrell of the Illinois Interagency Water Management/Conservation Committee; Shirley Hunt, Legislative Assistant for the Environment for Senator Durenberger of Minnesota (formerly with Upper Mississippi River Basin Commission); Denis Lussier, ERIC: and William E. Sharpe, Institute for Research on Land and Water Resources, Pennsylvania State University.

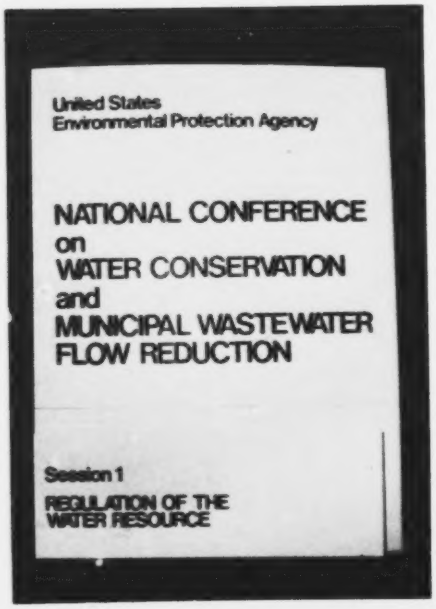
At the time of the conference itself, Jim Kashmier of the Division of Water Resources, Illinois Department of Transportation and his staff did yeoman service in attending to local affairs and arrangements, creating signs, and in many other ways contributed to the smooth running of the conference itself.

Dr. Willis E. Sibley, Professor of Anthropology at The Cleveland State University, Cleveland, Ohio, served as a program analyst in the Facility Requirements Division in 1978 under terms of the Intergovernmental Personnel Act. In that capacity he had the general responsibility, under the leadership of Michael B. Cook, Director, Facility Requirements Division, for planning, organizing and executing the conference.

Since the conference, primary responsibility for editing and preparing the Proceedings has fallen to Ms. Carol Freysinger of Enviro Control, Inc., with the continued guidance and cooperation of Willis E. Sibley, and Denis Lussier of ERIC.

Special materials for handouts to conference attendees were prepared by the National Association of Counties Research, Inc., and by the Clean Water Action Project, under EPA grants.

Many others contributed ideas, time and effort; though not all can be named, they are warmly and sincerely thanked.



United States
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NATIONAL CONFERENCE
on
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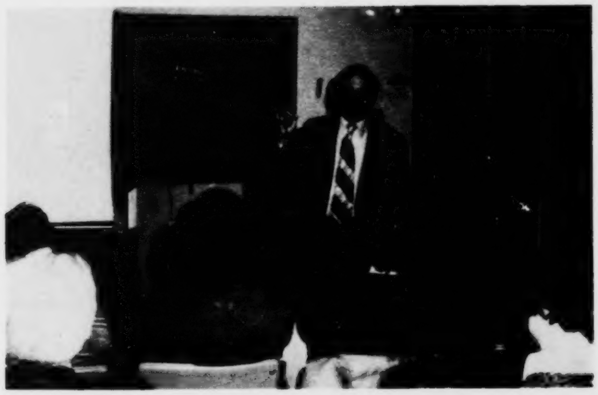
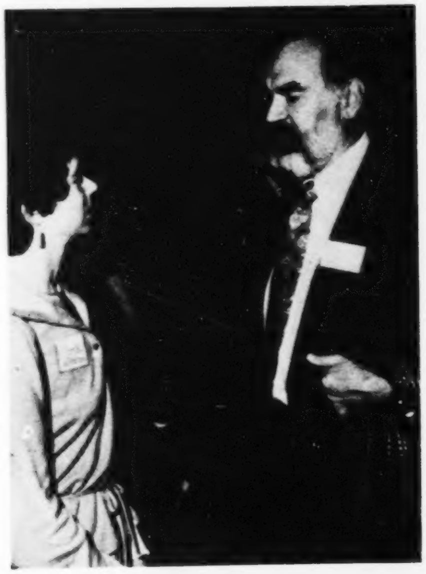
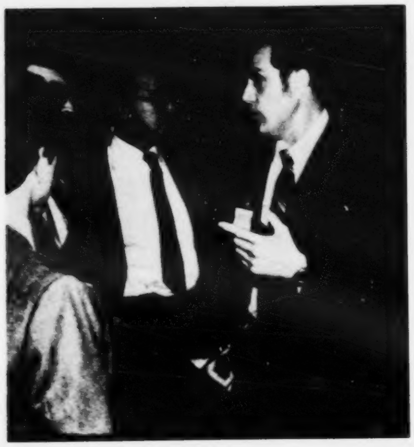
Session 1

REGULATION OF THE
WATER RESOURCE







Federal Water Policy

Jimmy Carter
President of the United States
Message to the Congress
June 6, 1978

I am today sending to Congress water policy initiatives designed to:

- -- improve planning and efficient management of Federal water resource programs to prevent waste and to permit necessary water projects which are cost-effective, safe and environmentally sound to move forward expeditiously;
- -- provide a new, national emphasis on water conservation;
- -- enhance Federal-State cooperation and improve State water resources planning; and
- -- increase attention to environmental quality.

None of the initiatives would impose any new federal regulatory program for water management.

Last year, I directed the Water Resources Council, the Office of Management and Budget and the Council on Environmental Quality, under the chairmanship of Secretary Cecil Andrus, to make a comprehensive review of Federal water policy and to recommend proposed reforms.

This new water policy results from their review, the study of water policy ordered by the Congress in Section 80 of the Water Resources Planning Act of 1974 and our extensive consultations with members of Congress, State, county, city and other local officials and the public.

Water is an essential resource, and over the years, the programs of the Bureau of Reclamation, the Corps of Engineers, the Soil Conservation Service and the Tennessee Valley Authority have helped permit a dramatiic improvement in American agriculture, have provided irrigation water essential to the development of the West, and have developed community flood protection, electric power, navigation and recreation throughout the Nation.

I ordered this review of water policies and programs because of my concern that while Federal water resources programs have been of great benefit to our Nation, they are today plagued with problems and inefficiencies. In the course of this water policy review we found that:

- Twenty-five separate Federal agencies spend more than $10 billion per year on water resources projects and related programs.
- These projects often are planned without a uniform, standard basis for estimating benefits and costs.
- States are primarily responsible for water policy within their boundaries, yet are not integrally involved in setting priorities and sharing in Federal project planning and funding.
- There is a $34 billion backlog of authorized or uncompleted projects.
- Some water projects are unsafe or environmentally unwise and have caused losses of natural streams and rivers, fish and wildlife habitat and recreational opportunities.

The study also found that water conservation has not been addressed at a national level even though we have pressing water supply problems. Of 106 watershed subregions in the country, 21 already have severe water shortages. By the year 2000 this number could increase to 39 subregions. The Nation's cities are also beginning to experience water shortage problems which can only be solved at very high cost. In some areas, precious groundwater supplies are also being depleted at a faster rate than they are replenished. In many cases an effective water conservation program could play a key role in alleviating these problems.

These water policy initiatives will make the Federal government's water programs more efficient and responsive in meeting the Nation's water-related needs. They are designed to build on fundamentally sound statutes and on the Principles and Standards which govern the planning and development of Federal water projects, and also to enhance the role of the States, where the primary responsibilities for water policy must lie. For the first time, the Federal government will work with State and local governments and exert needed national leadership in the effort to conserve water. Above all, these policy reforms will encourage water projects which are economically and environmentally sound and will avoid projects which are wasteful or which benefit a few at the expense of many.

Across the Nation there is remarkable diversity in the role water plays. Over most of the West, water is scarce and must be managed carefully--and detailed traditions and laws have grown up to govern the use of water. In other parts of the country, flooding is more of a problem than drought, and in many areas, plentiful water resources have offered opportunities for hydroelectric power and navigation. In the urban areas of our Nation, water supply systems are the major concern--particularly where antiquated systems need rehabilitation in order to conserve water and assure continued economic growth.

Everywhere, water is fundamental to environmental quality. Clean drinking water, recreation, wildlife and beautiful natural areas depend on protection of our water resources.

Given this diversity, Federal water policy cannot attempt to prescribe water use patterns for the country. Nor should the Federal government preempt the primary responsibility of the States for water management and allocation. For those reasons, these water policy reforms will not preempt State or local water responsibilities. Yet water policy is an important national concern, and the Federal government has major responsibilities to exercise leadership, to protect the environment and to develop and maintain hydroelectric power, irrigated agriculture, flood control and navigation.

The primary focus of the proposals is on the water resources programs of the Corps of Engineers, the Bureau of Reclamation, the Soil Conservation Service and the Tennessee Valley Authority, where annual water program budgets total approximately $3.75 billion. These agencies perform the Federal government's water resource development programs. In addition, a number of Federal agencies with water-related responsibilities will be affected by this water policy.

I am charging Secretary Andrus with the lead responsibility to see that these initiatives are carried out promptly and fully. With the assistance of the Office of Management and Budget and the Council on Environmental Quality, he will be responsible for working with the other Federal agencies, the Congress, State and local governments and the public to assure proper implementation of this policy and to make appropriate recommendations for reform in the future.

SPECIFIC INITIATIVES IMPROVING FEDERAL WATER RESOURCE PROGRAMS

The Federal government has played a vital role in developing the water resources of the United States. It is essential that Federal water programs be updated and better coordinated if they are to continue to serve the nation in the best way possible. The reforms I am proposing are designed to modernize and improve the coordination of federal water programs. In addition, in a few days, I will also be sending to the Congress a Budget amendment proposing funding for a number of new water project construction and planning starts. These projects meet the criteria I am announcing today. This is the first time the Executive Branch has proposed new water project starts since Fiscal Year 1975, four years ago.

The actions I am taking include:

- A directive to the Water Resources Council to improve the implementation of the Principles and Standards governing the planning of Federal water projects. The basic planning objectives of the Principles and Standards--national economic development and environmental quality--should be retained and given equal emphasis. In addition, the implementation of the Principles and Standards should be improved by:

-- adding water conservation as a specific component of both the economic and environmental objectives;

-- requiring the explicit formulation and consideration of a primarily nonstructural plan as one alternative whenever structural water projects or programs are planned;

-- instituting consistent, specific procedures for calculating benefits and costs in compliance with the Principles and Standards and other applicable planning and evaluation requirements. Benefit-cost analyses have not been uniformly applied by Federal agencies, and in some cases benefits have been improperly recognized, "double-counted" or included when inconsistent with federal policy or sound economic rationale. I am directing the Water Resources Council to prepare within 12 months a manual which ensures that benefits and costs are calculated using the best techniques and provides for consistent application of the Principles and Standards and other requirements;

-- ensuring that water projects have been planned in accordance with the Principles and Standards and other planning requirements by creating, by Executive Order, a project review function located in the Water Resources Council. A professional staff will ensure an impartial review of pre-construction project plans for their consistency with established planning and benefit-cost analysis procedures and applicable requirements. They will report on compliance with these requirements to agency heads, who will include their report, together with the agency recommendations, to the Office of Management and Budget. Project reviews will be completed within 60 days, before the Cabinet officer makes his or her Budget request for the coming fiscal year. Responsibility will rest with the Cabinet officer for Budget requests to the Office of Management and Budget, but timely independent review will be provided. This review must be completed within the same budget cycle in which the Cabinet Officer intends to make Budget requests so that the process results in no delay.

-- The manual, the Principles and Standards requirements and the independent review process will apply to all authorized projects (and separable project features) not yet under construction.

Establishment of the following criteria for setting priorities each year among the water projects eligible for funding or authorization, which will form the basis of my decisions on specific water projects:

-- The manual, the Principles and economic benefits unless there are environmental benefits which clearly more than compensate for any economic deficit. Net adverse environmental consequences should be significantly outweighed by economic benefits. Generally, projects with higher benefit/cost ratios and fewer adverse environmental consequences will be given priority within the limits of available funds.

-- Projects should have widely distributed benefits.

-- Projects should stress water conservation and appropriate non-structural measures.

-- Projects should have no significant safety problems involving design, construction or operation.

-- There should be evidence of active public support including support by State and local officials.

-- Projects will be given expedited consideration where State governments assume a share of costs over and above existing cost-sharing.

-- There should be no significant international or inter-governmental problems.

-- Where vendible outputs are involved preference should be given to projects which provide for greater recovery of Federal and State costs, consistent with project purposes.

-- The project's problem assessment, environmental impacts, costs and benefits should be based on up-to-date conditions (planning should not be obsolete).

-- Projects should be in compliance with all relevant environmental statutes.

  - Funding for mitigation of fish and wildlife damages should be provided concurrently and proportionately with construction funding.

- Preparation of a legislative proposal for improving cost-sharing for water projects. Improved cost-sharing will allow States to participate more actively in project decisions and will remove biases in the existing system against non-structural flood control measures. These changes will help assure project merit. This proposal, based on the study required by Section 80 of P.L. 93-251, has two parts:

  - participation of States in the financing of federal water project construction. For project purposes with vendible outputs (such as water supply or hydroelectric power), States would contribute 10% of the costs, proportionate to and phased with federal appropriations. Revenues would be returned to the States proportionate to their contribution. For project purposes without vendible outputs (such as flood control), the State financing share would be 5%. There would be a cap on State participation per project per year of 1/4 of 1% of the State's general revenues so that a small State would not be precluded from having a very large project located in it. Where project benefits accrue to more than one State, State contributions would be calculated accordingly, but if a benefiting State did not choose to participate in cost-sharing, its share could be paid by other participating States. This State cost-sharing proposal would apply on a mandatory basis to projects not yet authorized. However, for projects in the authorized backlog, States which voluntarily enter into these cost-sharing arrangements will achieve expedited Executive Branch consideration and priority for project funding, as long as other project planning requirements are met. Soil Conservation Service projects will be completely exempt from this State cost-sharing proposal.

  - equalizing cost-sharing for structural and non-structural flood control alternatives. There is existing authority for 80%-20% Federal/non-Federal cost-sharing for non-structural flood control measures (including in-kind contributions such as land and easements). I will begin approving non-structural flood control projects with this funding arrangement and will propose that a parallel cost-sharing requirement (including in-kind contributions) be enacted for structural flood control measures, which currently have a multiplicity of cost-sharing rules.

Another policy issue raised in Section 80 of P.L. 93-251 is that of the appropriate discount rate for computing the present value of future estimated economic benefits of water projects. After careful consideration of a range of options I have decided that the currently legislated discount rate formula is reasonable, and I am therefore recommending that no change be made in the current formula. Nor will I recommend retrocurrently authorized projects.

WATER CONSERVATION

Managing our vital water resources depends on a balance of supply, demand and wise use. Using water more efficiently is often cheaper and less damaging to the environment than developing additional supplies. While increases in supply will still be necessary, these reforms place emphasis on water conservation and make clear that this is now a national priority.

In addition to adding the consideration of water conservation to the Principles and Standards, the initiatives I am taking include:

- Directives to all Federal agencies with programs which affect water supply or consumption to encourage water conservation, including:
    - -- making appropriate community water conservation measures a condition of the water supply and wastewater treatment grant and loan programs of the Environmental Protection Agency, the Department of Agriculture and the Department of Commerce;
    - -- integrating water conservation requirements into the housing assistance programs of the Department of Housing and Urban Development, the Veterans Administration and the Department of Agriculture;
    - -- providing technical assistance to farmers and urban dwellers on how to conserve water through existing programs of the Department of Agriculture, the Department of Interior and the Department of Housing and Urban Development;
    - -- requiring development of water conservation programs as a condition of contracts for storage or delivery of municipal and industrial water supplies from federal projects;
    - -- requiring the General Service Administration, in consultation with affected agencies, to establish water conservation goals and standards in Federal buildings and facilities;

  - -- encouraging water conservation in the agricultural assistance programs of the Department of Agriculture and the Department of Interior which affect water consumption in water-short areas; and

  - -- requesting all Federal agencies to examine their programs and policies so that they can implement appropriate measures to increase water conservation and re-use.

- A directive to the Secretary of the Interior to improve the implementation of irrigation repayment and water service contract procedures under existing authorities of the Bureau of Reclamation. The Secretary will:

  - -- require that new and renegotiated contracts include provisions for recalculation and renegotiation of water rates every five years. This will replace the previous practice of 40-year contracts which often do not reflect inflation and thus do not meet the beneficiaries' repayment obligations;

  - -- under existing authority add provisions to recover operation and maintenance costs when existing contracts are renegotiated, or earlier where existing contracts have adjustment clauses;

  - -- more precisely calculate and implement the "ability to pay" provision in existing law which governs recovery of a portion of project capital costs.

- Preparation of legislation to allow States the option of requiring higher prices for municipal and industrial water supplies from Federal projects in order to promote conservation, provided that State revenues in excess of Federal costs would be returned to municipalities or other public water supply entities for use in water conservation or rehabilitation of water supply systems.

FEDERAL-STATE COOPERATION

States must be the focal point for water resource management. The water reforms are based on this guiding principle. Therefore, I am taking several initiatives to strengthen Federal-State relations in the water policy area and to develop a new, creative partnership. In addition to proposing that States increase their roles and responsibilities in water resources development through cost-sharing, the actions I am taking include:

- Proposing a substantial increase from \$3 million to \$25 million annually in the funding of State water planning under the existing 50%-50% matching program administered by the Water

Resources Council. State water planning would integrate water management and implementation programs which emphasize water conservation and which are tailored to each State's needs including assessment of water delivery system rehabilitation needs and development of programs to protect and manage ground water and instream flows.

- Preparation of legislation to provide $25 million annually in 50%-50% matching grant assistance to States to implement water conservation technical assistance programs. These funds could be passed through to counties and cities for use in urban or rural water conservation programs. This program will be administered by the Water Resources Council in conjunction with matching grants for water resources planning.

- Working with Governors to create a Task Force of Federal, State, county, city and other local officials to continue to address water-related problems. The administrative actions and legislative proposals in this Message are designed to initiate sound water management policy at the national level. However, the Federal government must work closely with the States, and with local governments as well, to continue identifying and examining water-related problems and to help implement the initiatives I am announcing today. This Task Force will be a continuing guide as we implement the water policy reforms and will ensure that the State and local role in our Nation's water policy is constant and meaningful.

- An instruction to Federal agencies to work promptly and expeditiously to inventory and quantify Federal reserved and Indian water rights. In several areas of the country, States have been unable to allocate water because these rights have not been determined. This quantification effort should focus first on high priority areas, should involve close consultation with the States and water users and should emphasize negotiations rather than litigation wherever possible.

ENVIRONMENTAL PROTECTION

Water is a basic requirement for human survival, is necessary for economic growth and prosperity, and is fundmental to protecting the natural environment. Existing environmental statutes relating to water and water projects generally are adequate, but these laws must be consistently applied and effectively enforced to achieve their purposes. Sensitivity to environmental protection must be an important aspect of all water-related planning and management decisions. I am particularly concerned about the need to improve the protection of instream flows and to evolve careful management of our nation's precious groundwater supplies, which are threatened by depletion and contamination.

My initiatives in this area include the following:

- A directive to the Secretary of the Interior and other Federal agency heads to implement vigorously the Fish and Wildlife Coordination Act, the Historic Preservation Act and other environmental statutes. Federal agencies will prepare formal implementing procedures for the Fish and Wildlife Coordination Act and other statutes where appropriate. Affected agencies will prepare reports on compliance with environmental statutes on a project-by-project basis for inclusion in annual submissions to the Office of Management and Budget.

- A directive to agency heads requiring them to include designated funds for environmental mitigation in water project appropriation requests to provide for concurrent and proportionate expenditure of mitigation funds.

- Accelerated implementation of Executive Order No. 11988 on floodplain management. This Order requires agencies to protect floodplains and to reduce risks of flood losses by not conducting, supporting or allowing actions in floodplains unless there are no practicable alternatives. Agency implementation is behind schedule and must be expedited.

- A directive to the Secretaries of Army, Commerce, Housing and Urban Development and Interior to help reduce flood damages through acquisition of flood-prone land and property, where consistent with primary program purposes.

- A directive to the Secretary of Agriculture to encourage more effective soil and water conservation through water shed programs of the Soil Conservation Service by:

    -- working with the Fish and Wildlife Service to apply fully the recently adopted stream channel modification guidelines;

    -- encouraging accelerated land treatment measures prior to funding of structural measures on watershed projects, and making appropriate land treatment measures eligible for Federal cost-sharing;

    -- establishing periodic post project monitoring to ensure implementation of land treatment and operation and maintenance activities specified in the work plan and to provide information helpful in improving the design of future projects.

- A directive to Federal agency heads to provide increased cooperation with States and leadership in maintaining instream flows and protecting groundwater through joint assessment of needs, increased assistance in the gathering and sharing of data, appropriate design and operation of Federal water facilities, and other means. I also call upon the Governors and the Congress to work with Federal agencies to protect the fish and wildlife and other values associated with adequate instream flows. New and existing projects should be planned and operated to protect instream flows, consistent with State law and in close consultation with States. Where prior commitments and economic feasibility permit, amendments to authorizing statutes should be sought in order to provide for streamflow maintenance.

CONCLUSION

These initiatives establish the goals and framework for water policy reform. They do so without impinging on the rights of States and by calling for a closer partnership among the Federal, State, county, city and other local levels of governments. I want to work with the Congress, State and local governments and the public to implement this policy. Together we can protect and manage our nation's water resources putting water to use for society's benefit, preserving our rivers and streams for future generations of Americans, and averting critical water shortages in the future through adequate supply, conservation and wise planning.

The Water Conservation Challenge

Ronald B. Robie
Director, Department of Water Resources
The Resources Agency
State of California

In moderating today's session, I have been asked to speak for a few minutes and set the stage for this two-day meeting on the subject of water conservation. Surprisingly enough, this subject, which would appear at first blush to be as American as apple pie, is more controversial and less of an obvious sure thing than most people realize.

The California drought of 1976-77 (which came a year after our Department began an intensive water conservation education program and after many local districts in California began similar efforts) showed that water users can significantly reduce their water use in most cases without serious lifestyle changes. However, lifestyle changes were required for drastic reductions in use, such as those in the Marin Municipal Water District. In compliance with a mandated cut of 57 percent, the District reduced its daily per capita consumption for single-family dwellings by 63 percent to an average of only 132 litres per day (35 gpd) during the 1977 drought rationing period. This level of conservation cannot be expected in more normal times, but our experience in California since the drought has shown that water use reduction can continue and should continue in normal and wet years.

For example, San Franciscans reduced their per capita use by approximately 28 percent during the drought. They are still approximately 22 percent below predrought levels when you compare the first nine months of 1978 to the same period in 1975. These reductions included consideration of both conservation and climate. As you probably know, in much of California, even in wet years, we have to irrigate our lawns and plants during the several months we get little or no rain. For the east side of San Francisco Bay, in the East Bay Municipal Utility District's service area, the per capita use during the drought was a reduction of approximately 35 percent. Today there is still a 24 percent reduction. Even in Los Angeles (which was never hit seriously by the drought) the per capita reduction during the drought was approximately 14 percent, and today it is 12 percent below predrought conditions. We are working on a technique to separate changes due to conservation from non-conservation factors such as climate. For Los Angeles we have identified a nine percent decline in water used during

1977 that can definitely be attributed to conservation efforts. If required to, people can save a lot of water. If urged and motivated to do so, they can still save quite a bit without the overwhelming public pressure of a drought.

Well, if this is true, why isn't water conservation occurring everywhere and why isn't conservation a "sure thing"?

First, many state and local water administrators still argue that "water conservation" means building dams and storing water, not reducing use. My response is simply that conservation means both. Water is conserved by storing it behind reservoirs for use at other times when it is needed. Water is also conserved and kept behind existing reservoirs or in existing underground sources by using less so that supplies are available for the future. These are simply two ways of meeting a single objective. I sometimes refer to them as the old meaning and the new meaning of the same word. Both are still valid. But all these semantic exercises mask a deep-seated fear that if people use less water, they'll need fewer water projects. They feel that water conservation is in competition with the way things have always been done; even with major water conservation efforts in the form of demand reduction we're still going to need new dams and new distribution systems and development of new ground water supplies. However, the cost of these developments has escalated tremendously in the past few years, especially in the West where good water storage sites are few and far between, and those that are available often have environmental problems associated with them. Stretching existing water supplies is realistic and cost-effective.

Second, the idea of reducing demand runs counter to the general utility philosophy of encouraging growth in water use. (How could anyone issue an annual report to show that income, customers, and product delivered were less than last year?) Most water managers won't admit this is a philosophy of water management at all. Thus, a shift now to a philosophy of discouraging water use, minimizing investment in capital facilities, and stretching our finite natural resources is considered an improper role for utility managers. Yet it is no more "social engineering" than prior efforts to encourage use. In California the drought taught many of those utility managers lessons that educational programs would have taken years to accomplish. But there is work to be done to get the great bulk of water utility managers in America to wholeheartedly subscribe to conservation as a major objective of their operations.

Third, for many years the Federal government has almost totally ignored conservation as a planning objective in its water projects. However, in a 180-degree change, President Carter, in his recent water policy, has made it the cornerstone of his program. The President said:

> Managing our vital water resources depends on a balance of supply, demand, and wise use. Using water more efficiently is often cheaper and less damaging to the environment than developing

> additional supplies. While increases in supply will still be necessary, these reforms place emphasis on water conservation and make clear that this is now a national priority.

The President further stated that he was directing all Federal agencies with programs which affect water supply or consumption to encourage conservation. He specifically included

> Making appropriate community water conservation measures a condition of the water supply and wastewater treatment grant and loan programs of the Environmental Protection Agency, the Department of Agriculture and the Department of Commerce.

The implementation of the President's policy should be significant in placing conservation in its appropriate place. Hopefully, the day of single-purpose Federal water planning is a thing of the past.

The U.S. Environmental Protection Agency has a particularly critical role to play in this area. Much of the water conservation that has occurred in the past in the municipal sector has come about in compliance with the requirements of the Clean Water Act, most particularly the imposition of pretreatment requirements and sewer service charges. This, together with the objective of eliminating discharges, has resulted in a reduction of waste flows and thus, water use, especially in the industrial sector. Until recently, little has been done in terms of conservation under EPA's Construction Grants program. With recent additions to the Construction Grants regulations, EPA has made conservation an integral part of its grant program.

I would like to add one final thought about water conservation. Water recycling is part of our overall conservation effort. In industry particularly, reductions in water use result from recycling supplies. Present Federal policies do not encourage reclamation, yet the reuse of wastewaters that have been treated as a result of massive expenditures of Federal funds provide an important part of our water supplies of the future and should be considered hand-in-hand with any other water demand reduction efforts and water development programs of the Soil Conservation Service, the Bureau of Reclamation, and the U.S. Army Corps of Engineers.

In California we are committed to conservation. We have been pushing it for four years as hard as we can. Our policy is to achieve maximum practical water conservation and the most efficient use of the waters of our state. While there is much work to be done in the agricultural conservation area, a subject which in most states we have just begun to explore, there is a real challenge ahead for everyone involved in water management to make conservation a meaningful part of our lives.

Water Conservation: Prospects and Problems

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Water and energy conservation have become popular subjects of conversation over the past few years, and rightfully so. Certainly they are subjects that will increasingly demand our attention. The time has come when we can no longer take for granted the natural resources that, in years gone by, have appeared to be limitless. It is incumbent on all members of our society to cooperate in transforming the problems of water and energy shortage into opportunities to discover how we can most effectively utilize those most precious resources.

This presentation will be devoted to defining the problems as seen by the speaker, and suggesting some approaches which will hopefully contribute to their solution. Examples will be introduced which, though based in some instances on hypothetical situations, nonetheless serve to illustrate the magnitude of our present wastefulness, and the potential we have to effect meaningful conservation with a minimum of sacrifice.

Available fresh water is presently limited to that which falls in the form of rain, ice, or snow. This water is eventually stored in natural or manmade lakes, cisterns, or some other form of reservoir, including the subsurface water strata and rivers. For all practical purposes, these sources cannot be significantly increased. Desalination of sea water offers one method of obtaining additional supplies, but the process is presently costly, and is feasible only along the nation's coastlines. Assuming we can develop the most effective means to collect and store the fresh water which falls, that we can draw from the subsurface reservoirs the greatest possible yield, and assuming that water can be delivered to the many points of consumption, the problems regarding the rate at which we use water are still very real.

The first step in the solution of any problem is an accurate analysis of the nature and extent of the problem. This step, in my judgment, has not yet been taken. One study, however, states that there are five major areas of water consumption, broken down as follows: electric utilities, 45 percent; agricultural, 34 percent; industrial, 13 percent; commercial, 4 percent; residential, 4 percent. I cannot speak for the validity of the study's findings, but, even allowing for a large margin of error, the greatest consumption of water occurs in areas other than residential, or even commercial. If this is indeed true, then it is clear that long-range water and energy conservation programs must put emphasis on the problem of the major consumers.

It is my belief that this will be done, and hopefully, in the not-too-distant future, even though the problems involved will be formidable. Electric utilities, for instance, cannot stop generating electricity, but they can--and I believe they will--reduce to the greatest possible extent both the water and energy they consume.

Undoubtedly vast quantities of water can be saved in the agricultural sector of our society. The amount of water, for instance, that is required to clean agricultural products as they are processed for consumption must be tremendous. If that water can be recycled without the expenditure of unreasonable cost or energy, then a giant step toward effective water and energy conservation will have been taken. Spray irrigation also needs to be studied closely. Some method of delivering water to the fields without spraying it into the air, with the resulting loss by evaporation, needs to be developed and implemented. Significant quantities of water could be saved, particularly in very hot climates with low humidities.

The industrial segment of our society presents one of the greatest challenges for water conservation. Too often, the water used by industry is heavily polluted with particulate matter or chemicals or, in some cases, both. Thermal pollution can also be a problem, but the rising cost of fuel will undoubtedly result in more of this waste heat being recovered. Removal of particulate matter, and especially the removal of chemicals, can be very difficult. It can involve huge initial costs for the design and construction of the necessary equipment, and often significant expenditures of money and energy to maintain and operate the systems. Since the most certain of all economic laws is that which states there is no such thing as a free lunch, we all might as well get used to the idea that we are going to have to pay for the water we save in this manner.

The areas where I wish to spend the most time are those of commercial and residential usage. Although they represent a small percentage of the total water used, these are the areas where engineers, contractors, manufacturers, and plumbing inspectors can make the greatest impact in the shortest possible period of time. By diligently seeking solutions to the problem of water conservation, and by implementing those solutions through realistic legislation and application of new technology as it is developed, we can lead the way in what promises to be a long and expensive endeavor.

Presently, the spotlight is on a relatively small number of water-saving devices. The industry has done a commendable job of making these devices available for a reasonable cost. These devices include flow-restricting aerators for lavatory and sink faucets, flow controls for shower heads, flush valves that operate with three gallons of water, urinals designed to flush with six quarts of water, and flush tank toilets that produce an adequate flush with three and one-half gallons of water. Although these devices may not sound impressive when considered individually, a quick analysis of the cumulative effect they could have, if installed, makes the significance of their contribution to the water conservation effort apparent.

For instance, consider a 500-unit apartment housing 500, four-person families--2,000 consumers of water packed into a single structure. For the purpose of evaluating the water consumption, I'll use the following assumptions which I believe to be reasonably accurate (these assumptions make an allowance for some of the family members spending a part of the day away from the apartment):

- each person uses the toilet four times a day
- each person runs the lavatory faucet for a period of two minutes a day
- each person spends six minutes a day in the shower.

Further, consider the following statistics on fixture flow rates which I believe are reasonably correct. The toilets currently in use in this country consume six to 11 gallons per flush. In the interest of being conservative, assume an average of eight gallons per flush. The average flow rate through a lavatory faucet, as it is normally used, is about 1-1/2 gallons per minute (gpm). Shower head flow rates vary from six to 10 gpm; eight gpm average seems reasonable, based on my experience in checking a number of installations. Using these figures, the water consumption for the apartment complex would be as follows:

- toilets: 16,000 gallons per day (gpd)
- lavatories: 1,500 gpd
- shower: 24,000 gpd
  The total daily consumption would be 41,500 gallons.

If the cost-conscious apartment owner could be convinced to install water-saving devices in the complex, the water consumption would be significantly changed: 3-1/2 gallon flush toilets would use 7,000 gpd; lavatories equipped with 3/4 gpm aerators would use 750 gpd; the heavy-use fixture, the shower, would consume only 9,000 gpd if equipped with a 3 gpm flow control device. The daily total of water consumed would be reduced to 16,750 gallons. Assuming that the residents of the apartments would be home for 50 weeks each year, the quantity of water saved would amount to 8,622,500 gallons per year.

As mentioned above, I believe these figures are fairly conservative, but assume that the annual savings is really only 7,500,000 gallons. To better visualize this quantity of water, think of a fish bowl the size of a football field. The water saved by this one apartment complex would stand approximately 22 feet above the bottom. If water cost $1.00/1,000 gallons--and it costs more than that now in some places--the apartment owner would realize an annual savings of $7,500.00. Obviously, the owner could pay back the initial investment in water-saving devices in a short period of time, and avoid the problem of increasing water cost for the water that would have been used.

The methods for conserving water outlined above are primarily directed toward new construction or renovation where the installation of devices is used to effect the desired results. There are other ways water can be conserved. They are easy and, best of all, they cost nothing to implement. How many persons reading this paper leave the faucet running while brushing your teeth? How about those men who do the same thing while shaving? I don't believe I have to quote any statistics to impress upon you the vast amount of water that could be saved if people would alter their lifestyles a bit, saving those little bits of water where they can. It would really be painless, and, if we have 220 million-plus persons in this country practicing some form of personal hygiene, you can see how literally hundreds of millions of gallons of water could be conserved each day.

There are other methods of conservation which have been tried with varying degrees of success, and innovative thinking will, I am sure, produce many more. I have heard, for instance, of one carwash installation in the Midwest which stores rainwater for use in its operation. By use of a filtering process, the water is used over and over, resulting in a sizable water--and dollar--savings. It seems that storage and later use of rainwater, when it can be done without excessive cost, holds promise for many non-potable water-consuming operations. Such water could be used for irrigation, to cite one possibility.

Proper maintenance of existing systems is another way significant quantities of water can be conserved. Leakage accounts for between 5 percent and 10 percent of all residential water consumed. Most of this is due to worn-out faucet washers and faulty toilet tank valves. A leaking faucet, leaking at a rate of one drop per second, can waste seven gpd; a steady drip, as much as 20 gpd. A leaking toilet tank valve can waste 200 gpd, and because the water leaks into the bowl, it is difficult to detect. Both of these water wasters can be repaired for little cost, and performing the required maintenance can save the owner enough to make it worthwhile.

Up to now, I have spoken primarily of water conservation, but solutions to the problem of water usage will have a highly desirable side effect: the conservation of energy. Practically all the water we use is pumped from a river or lake to a reservoir where it is treated. From the treatment plant, it is pumped either to an elevated tank, or directly to the consumer. Let's take another look at our 500-unit apartment complex.

Assume that the water serving the complex is taken from a lake, is treated, then pumped up to the complex located at an elevation 200 feet above the lake. Further assume that the water is delivered at 70 psig, by a 60 percent efficiency pump, at an average rate of 1/12 the total flow per hour for a 12-hour period. The reduction of the water consumed would result in a power savings of approximately 40 percent. There are, of course, other energy savings involved: that required to treat the water and to treat the effluent after the water is used; the fuel used in the vehicles required to transport the sludge and to deliver the chemicals; the fuel saved by not having to heat the vast quantities of shower water that would have been used with the old style shower heads; and many others.

At this point, I will end my discussion of ways of saving water in the immediate future. Hopefully, the things already said make it clear that there are many ways we can each become instant conservationists. It's simply a matter of being motivated to do the things we know how to do today. More importantly, what about the future?

I believe the overall, long term problem can be best solved through a nationwide concerted, coordinated effort in the areas of research, education, legislation, and administration, in that order.

First, what lies ahead in the area of research? We need one comprehensive research program--just one--funded by the Federal government and guided by a reasonably small group of persons from both the private and public sectors of our society. These persons should have the ability to first, ask the appropriate questions, and secondly, formulate those questions into a meaningful research program. Such questions might include the following:

- how much water is used by the various segments of our society, and does it vary geographically?
- what is the realistic potential for reducing the usage in each segment, and by what amounts?
- what are user habits related to plumbing fixtures? Conversely, how much can we expect to modify user habits and reduce the quantity of water used before we encounter technological or psychological barriers?
- what is the best means of achieving water conservation--water pricing, mandatory rationing, education, or some combination of the three?
- could, or should, the parameters for water use be standardized throughout the country, or should more extreme measures be made to apply in those areas with the most severe problems?
- what hydraulic problems will be associated with decreasing the flow in our existing sewers and sewage treatment systems?
- how much energy will be saved through implementation of proposed solutions, and how will the cost of that energy saved be passed on to the consumers?
- what are reasonable, and realizable, short term, midterm and long term goals?

Second, how can we most effectively inform the public of the results of such a research program, and of the proposed solutions that evolve from the research? I suggest that if one concentrated research program is planned and successfully completed, then one well-planned, coordinated, concentrated educational program should be implemented simultaneously across the country, one which has long and short term goals. Some short term goals could be achieved by spot reminders on radio and television, spotlighting various water-conserving measures and the money that could be saved by implementing them. It should be done in such a way that people begin to identify the problem and solutions with these spot reminders,in much the same way the government has had "Smokey the Bear" keep us aware of the hazards and destructiveness of forest fires.

Long term goals could be approached through the education of those responsible for design and construction of buildings, perhaps through films, seminars, etc. for architects, engineers, contractors, and developers. It's particularly important to reach the developers, since their money will be used to effect conservation. They must be convinced that increased initial costs are justified. Also, educational programs could be introduced into our schools, informing our children early in life of the contributions they can make in the conservation effort.

Once we have completed our research and formulated viable proposals for solutions, and once we have begun to educate the public of both the problem and the solutions, then--and only then--will we be ready to enter into a far-reaching, long term program of preventive and corrective legislation, one which will be both effective and acceptable to an informed public.

Third, what part will the legislative and bureaucratic process play in the conservation effort? President Carter, in his environmental message delivered on May 23, 1977, stated that "one of the pressing domestic issues facing the Administration and this Congress is the establishment of a national water resources management policy." He directed the Water Resources Council of the Office of Management and Budget and the Council on Environmental Quality to review existing water resources policy and recommend reforms. This basically means that the horse is already out of the barn--the legislative and bureaucratic wheels are already turning. It is my sincere hope that these wheels are rolling in the right direction. I don't mean by this statement to be critical of the individuals involved; I am sure they are sincerely striving to respond to the President's directive. My concern is that they will initiate too many programs and regulations before enough reliable data has been accumulated, resulting in programs which achieve minimal success at an extremely high cost, both in dollars and in poor public acceptance of the programs involved. Once such action is entrenched, the task of developing a really meaningful program becomes many times more difficult. For instance, if that one research group mentioned earlier bore fruit and produced meaningful data which could be developed into a reasonable, workable plan of action, one of the first things to logically follow would be the sponsoring of legislation to support those parts of the plan requiring the force of law to make them successful. Given good information, I am confident that our representatives have the desire and the motivation to initiate and pass such legislation. If, at that point, there are already regulations in effect being administered by one or more bureaus, the problem of developing new legislation is intensified by the need to nullify those regulations which conflict with the research group's perception of what should be done.

It seems that a basic decision has to be made before we become too deeply involved in the solutions to the problem of water conservation: who will finally be responsible for developing the program. That decision has already been made. It is my sincere hope that some group well-represented by both the government and the private sectors, who must live with the programs developed, can intervene before the government goes much further; that they can present to the Water Resources Council some alternative to the bureaucratic solution. Far-reaching but poorly thought-out programs developed before adequate data is available can result in several giant steps backward in the long term effort to conserve water.

I believe there is a time when the task of seeking solutions to the problems of our society should be shared by the private sector--by those persons knowledgeable in the subject, who must ultimately live with and function under the programs evolved. I believe that time is now.

Fourth, and last, what major role can our local and state administrative authorities play in such a nationwide, coordinated effort to conserve water?

Once the facts are known and plans have been developed, and once the legislative process has given us the necessary, but reasonable and workable, laws to establish our goals and limits, our local administrators become the key to the program's success. Plumbing ordinances will have to be changed to both reflect the national effort and to consider problems unique to their areas of jurisdiction. Flow-control and water-saving devices should be standardized throughout the country to help manufacturers avoid the problem of differing regulations. This is important for at least two reasons. First, it will allow those devices to be produced at the least possible cost, and second, it will minimize the stocking, shipping, and delivery problems that can result in construction delays.

Our various professional, technical, and trade societies which bring us together will each need to work closely with their own chapters, and with other societies, to aid our administrative authorities in whatever ways possible. Effective communication will be a major key to the timely success of any water conservation effort.

In conclusion, I wish to state my belief that the water conservation problem will be transformed into an opportunity. This will happen because people in this country have always had the ability and the determination to forget local prejudices and to combine forces in a remarkable manner when faced with a common problem. The group assembled here has the opportunity and the ability to make a major contribution to the efforts which will be required in the coming years. It is my hope that the Federal government, with its vast resources, will join hands with the private sector, vitally interested in the problem, as it seeks solutions and develops programs that will affect all of our lives for many years to come.

The Need for Water Conservation
The National Viewpoint

Leo M. Eisel
Director
U.S. Water Resources Council

Water conservation is doing with one gallon what any fool could do with ten.

Water conservation is, or ought to be, our first alternative rather than our last resort.

Water conservation is here and now. It is practical, painless, popular, profitable, and even patriotic.

Water conservation is the cornerstone of President Carter's National Water Policy announced in June of 1978. In his environmental message of May 1977 he ordered a thorough review of national water policy and indicated that any reforms proposed should have water conservation as their cornerstone. And after 18 months of study, review, hearings, and debate, his directive has been carried out: water conservation is the cornerstone of National Water Policy.

The four major themes of the President's water policy message are:

1) improved planning and management of Federal water resources programs;
2) a new national emphasis on water conservation;
3) enhanced Federal-state cooperation; and,
4) increased attention to environmental quality.

On July 12, 1978, President Carter issued a set of 13 implementing directives to the Federal agencies responsible for accomplishing objectives outlined in the National Water Policy. Each Federal agency assigned a specific task by these directives is required to seek appropriate input from State, county, local, and nongovernmental agencies in development of the implementation plans. Nineteen task forces are now at work implementing the directives.

Specifically, these directives address the following subjects.

- Water Conservation and Flood Plain Management
- Environmental Quality and Water Resources Management

- Improvements in the Planning and Evaluation of Federal Water Resources Programs and Projects
- Enhanced Federal-State Cooperation in Water Management
- Improvements in Soil Conservation Service Programs
- Conservation Pricing of Water Supplied by Federal Projects
- Technical Assistance for Water Conservation
- Water Conservation at Federal Facilities
- Water Conservation Provisions in Loan and Grant Programs for Water Supply and Treatment
- Agricultural Assistance Programs
- Water Conservation in Housing Assistance Programs
- Emphasis on Nonstructural Flood Protection Methods
- Federal and Indian Reserved Water Rights

Water Conservation and Flood Plain Management in Federal programs is one of the primary implementing directives in meeting the series of water conservation initiatives in the Water Policy Message. All executive departments and agencies have been directed to identify their respective programs having significant water use or conservation impacts, and to determine potential administrative or legislative changes that could be made in order to eliminate wasteful and unnecessary water use.

Improvements in the Planning and Evaluation of Federal Water Resources Programs and Projects is another key directive which has been issued to "achieve economic efficiency and environmental quality in water resources management." Specific improvements in the water projects planning and evaluation process are called for, along with the establishment of an independent water project review function, and formulation of specific criteria to be used as part of the decision process on potential water projects, and to be made public.

In the planning and review of water resources projects, the President stated that water conservation, which makes sense both environmentally and economically, has not been emphasized in Federal water projects and in some cases the Federal government has created disincentives to conservation. To help overcome this problem, the Water Resources Council (WRC) and its member agencies have been directed to carry out a thorough evaluation of current agency practices for making benefit and cost calculations, and to publish a planning manual that will ensure that benefits and costs are estimated in compliance with the Principles and Standards, which are the guidelines for preparing and evaluating Federal water projects, and other applicable economic evaluation requirements. In order to provide greater consideration of water conservation and nonstructural alternatives in all projects and programs subject to the Principles and Standards, WRC is directed to modify the Principles and Standards to accomplish the full integration of water conservation into project and program planning and review it as a component of both economic development and environmental quality objectives. This effort is now underway and a draft of the planning manual and the Principles and Standards revisions will be published for comment in March.

President Carter has indicated that the States should be the focal point for water resources management. To aid in accomplishing this objective, the President has issued a directive to WRC for Enhanced Federal-State Cooperation in Water Management by providing increased assistance to the states to establish water conservation technical assistance programs and to increase existing State water planning programs. Under this directive, a $25 million program for water conservation technical assistance grants to States will be implemented by the Water Resources Council.

A directive has also been issued regarding Conservation Pricing of Water Supplied by Federal Projects. The Departments of Interior, Agriculture, Energy, Army, and the Tennessee Valley Authority (TVA) have been directed to arrange for current audits of all major Federal water supply and power projects to "establish the financial condition, including operation and maintenance costs, of these projects." Further, all new water supply and power contracts shall include a provision calling for recalculation of water rates every five years. In addition, provisions should be added to recover operation, maintenance, and replacement costs when long term contracts expire or earlier where existing contracts have adjustment clauses.

Another directive calls for increased Technical Assistance for Water Conservation in water-short areas, both agricultural and urban. Consequently, the Departments of Interior, Agriculture, and Housing and Urban Development are preparing a plan for identifying and providing increased water conservation technical assistance to qualifying water-short areas using existing assistance programs.

Water Conservation at Federal Facilities also is included in the Water Policy directives. In consultation with WRC and affected agencies, the General Services Administration is directed to review water use at Federal buildings and facilities under its jurisdiction, and to specify water conservation measures and establish specific standards and goals for water conservation at these sites in order to increase the efficiency of water use during the period from 1979-1983.

The directive on Water Conservation Provisions in Loan and Grant Programs for Water Supply and Treatment requires certain Federal agencies to review those programs that provide loans and grants for urban water supply and wastewater treatment systems, modify those programs to remove any disincentives to water conservation, and to require appropriate community water conservation programs as a condition of such loans and grants. These water conservation modifications are to apply to all loans and grant programs awarded after September 30, 1979.

As part of the directive on Agricultural Assistance Programs in water-short areas, the President has indicated a need to discourage overextension and ground water depletion in such areas where Federal agricultural assistance programs are operating. Consequently, the Departments of Agriculture and Interior are instructed to develop appropriate actions to achieve this goal. These actions are to be coordinated, wherever possible, with the water conservation technical assistance program called for in other directives.

The Water Conservation in Housing Assistance Programs directive calls for the adoption of low-cost conservation measures. Consequently, a review will be taken of existing housing assistance programs in order to modify those programs where necessary to require the adoption of low-cost conservation measures. All housing assistance provided after September 30, 1979 will include these water conservation modifications.

The term "water conservation" was used 17 times in the President's message to the Congress--and it is implied, across and throughout, many more times.

One of our first efforts has been to develop a common definition, or concept, of water conservation--not too surprisingly a difficult task. Presently, we're using the definition in the President's message, the basic idea being that water conservation is primarily concerned with reducing demand for water.

As we revise the Principles and Standards which guide Federal water planning we will require that, in order to fully incorporate water conservation, water resource planning will be based upon a systematic evaluation of alternative management strategies--structural and nonstructural measures--which will

1) modify the demand for water for selected purposes;
2) enhance the use of existing water development facilities; and
3) develop new supplies.

Water conservation is not to be sought as a goal in itself, but rather one very effective tool to be used in meeting our national objectives of insuring a safe and dependable water supply for all uses.

The concept of conservation does not exclude the development of new water storage facilities, but it does indicate that new supply should not always be, as it has in the past, the preferred measure for meeting our water needs. Finally perhaps, the management of demand will precede the management of supply.

It has been said about our government structure that local governments have all the problems, State governments have all the authority and the Federal government has all the money. That certainly fits the water resources picture quite well today, but there are some indications of change. Earlier this fall, Congress indicated that the Federal tax bite ought to be a bit less. Also, the President said in his successful veto of the Public Works Appropriation Bill that we will no longer use the Federal dollar to solve every real or imagined water problem that comes calling.

We learned, or relearned, during the Water Policy Study that the Federal government is not the preeminent water management authority--water allocation is controlled by State law and primary water management responsibility is at State level. Even in the West, water from Federal reservoirs is less than 40 percent of the total. And while the annual Federal investment in water resources is large, with over $10 billion allocated for water quality and water resources development, it is probably less than the local, state and private investment in water supply faciliites.

Water conservation will not be accomplished by Federal decree. We can urge and cajole and sometimes bribe the water users and water managers, but there is no way that we can, or want to, mandate water conservation. Education and incentives and practicing, I hope, what we preach will be our major efforts.

If water conservation is to become effective, it will happen out here in the real world, through the understanding and perseverance of people such as are assembled here today. You are the troops in the front lines and you are the leaders who can help us become wise water users.

The water conservation technical assistance grants program ($25 million for State grants) is intended to help you to help each other. The opportunities for water conservation are different in different states and different regions, and if we can set 50 States and their local water managers to work in a general direction, the resulting water conservation programs will surpass by a hundredfold what any Federal bureaucrat might think up, let alone implement.

This program will provide funds on a matching basis to all States--an equal share to each and a variable share based on population and water use. States will be able to use these funds for public education and information dissemination, technical assistance and, principally in the appropriation state, water exchanges (legal exchanges of water use rights between jurisdictions in times of need). Legislation to authorize this program will be introduced in January; we have drafted the rules and will be ready to implement the program as soon as we have the authority. These rules quite broadly interpret what may be included in water conservation and in technical assistance, and will require the designated State agency to coordinate its technical assistance program with local governments in the use of funds.

Water conservation will not solve our water problems overnight, but it doesn't need to. It has taken us years of overinvestment and overexpansion to get into this box and it's not unreasonable to expect that it will take a few years to change our ways. Even with a now-declining or stable birth rate, it has been said that we as a nation will build by the end of the century additional physical plant--homes, offices, and factories--equivalent to that which exists today. And if each of these facilities incorporates the water conservation devices which are now practical, our children and our children's children will be doing with one gallon what we used to do with ten.

To summarize the national viewpoint, there is no national water crisis--and with a nationwide emphasis on water conservation, there doesn't need to be and won't be. We do have severe water supply shortages in certain local areas because we insist on moving into areas where the water is not plentiful or accessible.

Nationally, we have an available supply in our surface waters of 1300 billion gallons per day. From this we withdraw less than a third and we consume less than a tenth. But there is no national plumbing system and a surplus or a savings in one region has little use in another region far removed. Since 1920, more than half of all Americans have become urban dwellers and we have concentrated our homes and industry on 5 percent of the nation's land area. Our urban water consumption is only 6 percent of our national total, but because this use is so concentrated, there is and will continue to be intense competition for the existing supplies and the limited new supply potentials. Small improvements in our efficiency of domestic water use--and water savings of 20 to 40 percent are entirely practical and possible--can provide that equivalent of new supply, at zero investment. And the equivalent new supply requires no transmountain diversion, no massive reservoir, and no Federal subsidy.

The national role in water conservation will be cooperation, not preemption. We will eliminate the Federal incentives to waste water; we will establish a few incentives to conserve. And we will lean heavily upon you in the water business to carry the message to the people--to increase water consciousness if you can--or reduce their water pressure if you can't. We'll all save water either way.

Legislative Impacts, EPA, and Water Conservation

Thomas C. Jorling
Assistant Administrator for Water and Waste Management
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John Wesley Powell was one of the first American scientists to study, appreciate, and write about the problems and opportunities related to water in the arid and semiarid West. In his classic study, Lands of the Arid Region of the United States, published in 1878, Powell wrote, "where agriculture is dependent upon an artificial supply of water, and where there is more land than can be served by the water, value inheres in water, not in land; the land without the water is without value." He also predicted many natural and human disasters--floods, droughts, crop failures, and disputes over land and water rights--which could result from mismanagement of a scarce resource.

Many of Powell's predictions have been realized in the subsequent years. The environmental implications of a finite water supply--most acute in the Western States--have now appeared in other parts of the country and in other parts of the world. Water shortages have caused the latest rude awakening from the American Dream. One more assured amenity of an unlimited, cheap supply of fresh water can no longer be taken for granted. While the amount of water remains relatively static, the demands for it expand exponentially.

In the Western States, competing demands include growing population centers and expanding industrial and agricultural bases. The exploitation and conversion of native energy resources, including coal, oil shale, and uranium, will require vast additional amounts of water. At the same time, we are realizing that the traditional water resource solutions--great reservoirs and interbasin transfers of water--are either no longer economically feasible or are politically and environmentally unacceptable.

Eastern States are also experiencing serious water shortages. Primarily, this is a result of poor quality restricting the quantity available for competing uses. Both water supply and wastewater facilities in the East are in serious need of expansion and rehabilitation. Water development, treatment, and heating are energy-intensive and expensive. Wastewater collection, treatment, and disposal share the same problems.

These competing demands throughout the country and the constraints of a finite water supply are urging us toward a carefully integrated process of water resource management. It makes little sense to spend hundreds of millions to clean up the effluent discharges into a river only to have the impact of that investment negated by increasing upstream withdrawals. Conversely, water resources development plans which fail to treat quality considerations in the development equation are an anachronism which we can no longer afford.

I recognize there are some dangers and limitations associated with the land application alternative. Industrial effluents can contain heavy metals such as cadmium and organic chemicals with phytotoxic effects. Human pathogens and intestinal worms are often associated with untreated wastewater. However, pretreatment, abatement of pollutants, and disinfection can reduce many of these problems. Careful site management can prevent excessive runoff, reduce odors, and protect human health and the biological integrity of ground and surface water.

Congress has encouraged development of projects and technology which reuse and recycle wastewater in both the 1972 and the 1977 Amendments to the Federal Water Pollution Control Act. The decision and administrative action to emphasize and encourage reclamation within the U.S. Environmental Protection Agency predate the 1977 amendments. On October 3, 1977, a policy statement from EPA Administrator Costle to the Assistant Administrator and the Regional Administrators stated that the Agency would "press vigorously for publicly owned treatment works to utilize land treatment processes to reclaim and recycle municipal wastewater." This policy statement reflected the Administrator's understanding of the original intent of Public Law 92-500: to encourage development of wastewater management policies based on the fundamental ecological principle that all materials should be returned to the cycles from which they were generated. In that memorandum, he urged particular attention to wastewater treatment processes which renovate and reuse wastewater as well as recycle the organic matter and nutrients in a beneficial way.

The 1977 Clean Water Act reiterated and strengthened the directive to EPA contained in the 1972 amendments to apply conservation principles and to preferentially consider reclamation and recycling processes and technology. EPA is now moving ahead with water conservation initiatives on several fronts--through training programs, regulations, research and development, special studies, and through participation on Federal interagency task forces.

An important thrust of our efforts is to incorporate water conservation measures into the facility plans for municipal treatment works. Following a directive from President Carter, the Agency has assumed leadership for an interagency review of all Federal loan and grant programs for water supply and wastewater treatment. This is part of the implementation of the President's National Water Policy, aimed at making water conservation a prerequisite of these Federal grant and loan programs.

The President's directive applies to grant and loan programs administered by the Departments of Agriculture, Commerce, and Housing and Urban Development, as well as those of EPA. We are directed to examine possible program modifications that would remove existing disincentives and provide new incentives for water conservation as a condition of the grant or loans awarded after September 30, 1979. The work of the Interagency Task Force is already underway. A progress report will be submitted by the end of November 1978.

EPA has been moving ahead of the Interagency Task Force on a parallel and complementary track by incorporating water conservation requirements into revisions of the construction grants regulations. The recent revisions to the construction grant cost-effectiveness guidelines establish an upper limit on the estimate of average daily per capita flows built into the project design where flows are not well documented. In many cases this should work to limit the size of the treatment facility and encourage communities to install water-conserving devices in the system. To reinforce this, the cost-effectiveness guidelines require that each facility plan include an estimate of the costs, the cost savings, and the effects of installing and implementing flow reduction measures. These measures are to include public information programs, pricing and regulatory approaches, the installation of water meters, and the retrofitting of homes, offices, and commercial facilities with water-conserving devices. The grantee will also be required to examine local ordinances relating to building and plumbing codes to encourage installation of water-saving devices.

The Clean Water Act provided the Construction·Grants Program additional legislative tools to encourage water conservation through application of innovative and alternative technologies. In adopting these provisions the Conference Report expressed the disappointment of the Congress that the provisions of the 1972 amendments to encourage alternatives that would "lead to reclaiming and recycling of water and the confined and contained disposal of wastes" had not been effectively implemented.

The Clean Water Act provides increased financial incentives to the community to consider the alternatives to conventional wastewater treatment systems. The inducements include an increase from 75 percent to 85 percent in the eligible Federal share of the project costs; a two percent set-aside of the States' allotment to provide the increased Federal share for exclusive use on innovative and alternative projects; a failsafe feature which protects the community against financial liability in the event that the project fails to operate properly and at a reasonable cost; and 100 percent Federal funding of technical evaluations, training, and information dissemination associated with such projects.

New and innovative technologies must be considered in the development of each facility plan. This is no longer optional. Moreover, such projects now enjoy a 15 percent edge over conventional treatment systems in the cost-effectiveness analysis. I might add here that land application methods are specifically mentioned in the definition of the terms "innovative and alternative." At present, over 13 percent of the step one, two, and three construction grant projects have land application components.

Another area in which EPA has the opportunity to exert some influence upon water use is with industrial wastewater control. Section 301(i) of the Clean Water Act establishes water conservation as one of the legitimate conditions for allowing the extension or modification of a National Pollution Discharge Elimination System (NPDES) permit (Section 402) for an industrial discharge into a publicy owned treatment works not in compliance with the

1977 deadline. This affects approximately 2400 major treatment systems and could be applicable to thousands of industrial discharges.

Additionally, the Agency is in the process of initiating a major program for the control and pretreatment of toxics from industrial dischargers into municipal systems. The establishment of user fees based on volume and loading have had a demonstrated effect on lowering the amount of water used by these dischargers in the industrial process. Removal and control of toxics in the production process will greatly expand the potential utility and acceptability of the discharge for other purposes.

The Clean Water Act contains three additional amendments with potential for water conservation benefits. Section 516(e) requires EPA to submit to Congress a report with recommendations for legislation on a program to coordinate water supply and wastewater control plans as a condition to grants for construction of wastewater treatment works.

A work group has been established to study this matter and will focus on such issues as:

- Water conservation as a potential means for accommodating growing needs with available supplies, improving water quality, and realizing monetary and energy savings in both water supply and wastewater treatment
- The tradeoff between additional wastewater treatment to protect drinking water sources or sophisticated water supply treatment when water is withdrawn from those sources for use
- The adequacy of ground water source protection in light of potential increases in land treatment, recharge with wastewater, and injection as a means of disposal.

The recently-established work group has developed an extensive schedule of informal workshops at five EPA regional offices to involve the States. localities, public groups, industries, and others in developing the report. These workshops will be held from mid-January to mid-February 1979, and I encourage those of you here today to participate. Formal hearings on a preliminary report will be held during the summer.

A second initiative, called for by Section 102(d) of the Clean Water Act, is the preparation of a report to Congress on the relationship of EPA's water quality program and other State and Federal programs for water quantity allocation.

The task force preparing the report will study water quality/quantity program relationships at the Federal, State, and regional and interstate levels. The report will identify and analyze existing technical, economic, institutional, and legal problems and constraints. Some specific issues to be examined from this perspective include instream flow, irrigated agriculture, consumptive waste treatment technologies, and surface and ground water interrelationships.

The task force expects to have a final report by next spring. In the meantime, it will work closely with groups outside EPA, including the States, river basin commissions, and other Federal agencies. A public meeting on a draft report is also planned for early spring.

Finally, a work group is developing an EPA policy on multi-purpose projects to guide the application of construction grants to such purposes. The group is studying water reuse and reclamation as well as other types of multi-purpose projects.

CONCLUSION

Through these initiatives and through additional efforts that the Interagency Task Force will be developing, the Environmental Protection Agency will insure that its programs--and projects affected by its grants and regulations--will include or seriously consider all available options to conserve water. EPA's water resources management policy will encourage coordinated consideration of the quality/quantity relationship. It will encourage multiple-use projects. It will attempt to make available to the maximum number of beneficial competing activities water of the highest quality. Reuse and recycling will be the essential mechanisms encouraged by EPA.

However, it must be realized that the potential impact of the Federal government is limited. The potential impact of all levels of government is limited. Water conservation is most critical at the level of the individual. In the past, most efforts to conserve resources have followed crisis: shortages, droughts, oil embargoes, contamination. The initial enthusiasm dissipates quickly as the crisis passes. But the problem remains. The interrelation of all finite natural resources must be appreciated by the individual. Efforts must immediately be made to integrate provisions for conservation into our individual lifestyles, so that we do not preclude other beneficial uses in our generation and in the years ahead.

Water Conservation and the Environment

J. Gustave Speth
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Council on Environmental Quality

Theodore Roosevelt was the first 20th century President to elevate protection and conservation of water resources to a level of national significance. He wrote in his autobiography that,when he assumed the Presidency,

> Our magnificent river system with its superb possibilities for public usefulness, was dealt with by the national government not as a unit, but as a disconnected series of pork-barrel problems, where the only interest was in their effect on the re-election or defeat of a congressman here and there.

Roosevelt's natural resource policy reflected his belief that "the forest and water problem are perhaps the most vital internal problems of the United States." Roosevelt sponsored and signed the Reclamation Act of 1902, which provided for the reclamation of vast public lands by irrigation. He created the Inland Waterways Commission in 1907 to consider the relation of the nation's rivers and streams to its other resources. And in 1908 Roosevelt assembled the National Conservation Commission. This conference of governors, congressmen, Supreme Court Justices, members of the Cabinet, and other distinguished individuals prepared an inventory of the natural resources of the country and wrote recommendations for their wise management.

Unfortunately, not many of their recommendations were implemented. Following World War I, the nation's fresh water was increasingly viewed as an unlimited resource, to be harnessed, tapped, and diverted for agricultural, municipal, and industrial development. Water was the source of hydroelectric development. Conservation was defined in terms of flood control, harnessed energy, or construction of major basin and interbasin diversions to correct nature's uneven geographic distribution of its hydrologic abundance. And after World War II, Congress greatly expanded Federal funding of large multipurpose water development projects.

However, a number of intervening reviews of the Federal government's role in water resources development were increasingly critical of this approach. The National Water Commission's 1972 report, for example, urged reforms in planning, cost-sharing, and coordination, and emphasized the need for water conservation and consideration of environmental values.

During this decade, we also began to understand the complex interrelationships between the quantity of water in a particular stream, river, or lake; its flow and hydrologic cycles; and the support and maintenance of the associated aquatic environment. The importance of protecting ground water reservoirs also became evident, though too often in the context of local water shortages and environmental crises.

Responding to these changing values, President Carter in 1977 ordered a full-scale Executive branch review of water policy at the national level.

The Water Policy Message delivered to Congress by the President on June 6, 1978, is based upon the specific findings of this Water Policy Review, which was conducted by the Office of Management and Budget, the Council on Environmental Quality, and the U.S. Department of the Interior.

The review pointed out that, despite the numerous benefits that Federal water programs have provided, their blessings are indeed mixed. Many projects have caused serious environmental, economic, and safety problems. The review found a pressing need for comprehensive and consistent executive oversight and direction of the 25 Federal agencies which spend more than $10 billion per year on water resource projects and programs.

More specifically, the study discovered that many Federal programs include no incentives to conserve water. It also highlighted the most serious problem areas in the country--where water needs are greatest, where water use is excessive, and where conservation could free water for other competing uses.

According to data gathered, a severe water shortage now exists in 21 of 106 subregions of the United States--located primarily in the Central Plains and Southwestern States. A potentially severe shortage is projected for 18 additional regions by the year 2000, if consumption grows as projected.

Over 90 percent of the water consumed in the subregions (with identified imbalances in water supply and demand) is used by agriculture, particularly for irrigation. In many parts of these subregions, farmers and other water consumers are drawing upon a fixed supply of ground water which cannot be renewed, or can be replaced only at a high cost. Such ground water mining is most prevalent in the Texas High Plains region and other parts of the West. The same water is sought by energy-generating industries as well as spreading metropolises. Phoenix, Denver, and Tucson present good illustrations of the problem of ground water mining.

As a nation, one of our problems has been our steadfast refusal to accept the limitations that nature itself has imposed on the regional distribution of this most precious of resources. Failing to accept that limitation on the social, cultural, and economic development of an area, we have not been compelled toward conservation, or even particularly wise use.

Historically, our solutions to water distribution problems have been structural: expensive, energy-intensive, and, too frequently, environmentally damaging. The adverse environmental implications of dams and diversions were only learned after years of observation. But we must now profit from our experiences. For example, in-stream resources such as fisheries cannot be sustained during critical periods of low flow and high temperatures, if impoundments or diversions further reduce minimum in-stream flow.

The President's water policy addresses these problems in several ways: changes in pricing, Federal program reform, and technical and planning assistance. One important innovation is a set of criteria for selection of projects for Federal funding. These criteria will encourage water projects which are economically and environmentally sound and will avoid projects which are wasteful or which benefit few at the expense of many. One of these criteria is that eligible projects should stress water conservation and appropriate nonstructural measures. The new, more stringent criteria were put to a strong test in October 1978, as the President successfully vetoed the Public Works Appropriation Bill. One of the reasons for the veto was that the bill included funding for several projects which did not meet the new criteria.

On July 12, 1978, the President issued 13 directives to the various Federal water agencies to implement new Federal water policy objectives. For example, a directive to the Secretary of Agriculture seeks to encourage accelerated land treatment measures through the Soil Conservation Service (SCS) prior to funding of structural measures on watershed projects. It also directs the SCS to make appropriate land treatment measures eligible for Federal cost-sharing.

Eight of these directives stressed conservation of water, which, as you know, the President has made the "cornerstone" of his water policy. Because questions have been raised about what is included in this emphasis on water conservation, let me address that issue.

As a participant in the preparation of the Water Policy Message and those directives, I can assure you that "water conservation" is intended to mean measures to reduce demand for ground and surface water withdrawals and to improve the efficiency of agricultural, municipal, and industrial water use. The emphasis is certainly not intended to provide justification for increased dams and water storage. Federal support for additional water storage, whether for flood control, hydropower, or water supplies, must be justified in terms of the other criteria previously mentioned.

Another major element of the President's Water Policy--environmental protection--is advanced through directives to the Secretary of the Interior and other Federal agency heads to apply strictly the relevant environmental statutes, such as the Fish and Wildlife Coordination Act and the Endangered Species Act. The message also encourages increased cooperation with States and Federal leadership in maintaining in-stream flows and protecting ground water. This is a sensitive point because much of the legal authority for such measures lies with the States; however, there is an important role here for the U.S. Environmental Protection Agency to play in working with the States to develop mutually acceptable standards.

In view of the vital national importance of the various competing demands on water, it is clearly unacceptable for us to continue using our waterways as vehicles for pollutants. Such use of our water directly conflicts with other essential uses, including drinking water supply, recreation, and agriculture.

The thrust of our future water management efforts must be toward multiple use and toward restriction of environmentally damaging activities. In this regard, I am pleased to note that the Environmental Protection Agency has assumed a lead role in encouraging land application through its programs. Additionally, the Agency's efforts in implementing the Clean Water Act of 1977 have placed it in the forefront of Federal action to direct grant and loan programs toward fulfilling conservation objectives.

I have already described several Presidential initiatives. Others include:

- A directive to the Water Resources Council to improve implementation of the Principles and Standards governing the planning of Federal water projects by:
    a. adding water conservation as a specific component of both the economic and environmental objectives, and
    b. requiring the explicit formulation and consideration of a primarily nonstructural plan as one alternative whenever structural water projects or programs are planned
- Directives to all Federal agencies with programs which affect water supply or consumption to encourage water conservation, including:
    a. making appropriate community water conservation measures a condition of the water supply and wastewater treatment grant and loan programs
    b. integrating water conservation requirements into the housing assistance programs
    c. reform of pricing of water from Federal projects
    d. preparation of legislation to allow States the option of requiring higher prices for municipal and industrial water supplies from Federal projects to promote conservation (this option would require that State revenues in excess of Federal costs be returned to municipalities or other public water supply entities for use in water conservation or rehabilitation of water supply systems).

The President's policy thus expresses a new, national emphasis on water conservation and increased attention to environmental quality. It seeks to stimulate conservation and conservation initiatives in the private sector and in other branches of the Federal government. Under the President's policy, the Federal government will, for the first time, work closely with State and local governments, exerting needed national leadership in water conservation. Under the direction of Interior Secretary Andrus, 19 interagency task forces have been established to oversee the implementation of the water policy. These task forces are already at work, identifying appropriate programs for water conservation and other initiatives. The task forces have submitted work plans, and some have or will soon submit interim reports to Secretary Andrus, the Congress, and the public.

Some of the Water Policy Implementation Task Forces are proceeding with more dispatch than others. Unfortunately, task force representatives from some departments and agencies have indicated reluctance to consider modifications of their own Federal programs to accomplish water policy reform. This situation is disconcerting, and may require a reminder to some of those involved of the tasks and timetable assigned to them, and by whom.

An important role has been defined here for citizens: to be the advocates of water conservation and improved water management. The structure is, by design, open to public participation. Citizens can play a major role in ensuring meaningful execution of the President's directives. This may require some confrontation, imaginative compromising, and, ultimately, cooperation.

Such a process will define the path toward our goal of improved water management. Through improved management, the waters of the United States will be available for the many vital activities, both economic and environmental, which benefit our nation, as Teddy Roosevelt sought through his Commission's efforts 70 years ago.

Plumbing Codes and Water Use

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Throughout history, the development of adequate water and sewage systems has been a challenge to the growth of urban civilization. In certain parts of Europe, one can still see the complex aqueduct systems built by the Romans to supply their cities with potable water. Early systems for the disposal of human wastes, however, were hardly as elaborate. Often, human wastes were simply transported from cities in carts or buckets--or else discharged into an open, water-filled system of ditches which led from the city to a lake or stream.

Plumbing codes are a relatively recent phenomenon. The first plumbing code to achieve national prominence in the United States was promulgated by a commission appointed by President Hoover and published in 1928. It was the culmination of work started by a subcommittee on plumbing in the United States Department of Commerce as early as 1921. In 1928, the American Standards Association (presently known as the American National Standards Institute) organized a sectional committee to develop a preliminary national plumbing code. The committee spent 14 years developing a document, and produced its first edition in 1942.

The National Association of Master Plumbers published its first "Standard Plumbing Code" in 1938. It was revised in 1942.

In 1938, the Western Plumbing Officials (WPO) initiated the first draft of the Uniform Plumbing Code, marking the first time that plumbing officials developed their own code. The WPO, now known as the International Association of Plumbing & Mechanical Contractors Organization (IAPMO), is the only survivor of these early attempts to develop a model code.

In retrospect, the majority of plumbing technology advances have come during the last 115 years, with much of this headway being made since World War II. Today, we have new materials, methods, and modern, up-to-date codes for the installation and control of our plumbing-sanitary systems.

Today we have model plumbing codes such as the Basic Plumbing Code of BOCA; Standard Plumbing Code of the Southern Building Code Congress (SBCCI); the Plumbing, Heating and Cooling Contractors Code (known as the National Standard Plumbing Code), an attempt to rewrite the A-40 Code; the Council of American Buildling Officials' work on a consensus plumbing code; a new plumbing code by the International Conference of Building Officials (ICBO); and various State and local plumbing codes. These exist, along with an abundance of Federal regulations which directly and/or indirectly affect water conservation efforts with the pressures they place on code groups, industry, and the manufacturer.

The model plumbing codes in this country offer the best system to keep technology current. Since they are updated annually and are usually staffed with competent, able persons, they provide the forum for input and open and frank discussions of technological issues.

After enactment, the plumbing codes become a technical manual and the manual of operations for those who adopt and enforce them.

The model plumbing code processes do allow for the introduction into the marketplace of proprietary devices, appurtenances, and plumbing appliances through their research programs. This program allows a manufacturer to have his product evaluated against the code and then marketed with a recommendation from the model code groups that the product meets the intent and performance criteria of the code.

The oil embargo of 1973 brought to the American people the realization that our natural resources are limited. A word that had until this point found little use in modern American society suddenly became a byword: conservation. This term soon found its way into the daily lives of every American.

Water has always been an abundant resource, seldom conserved. Demands are continuously increasing while pollution continues to shrink useable supplies. For this reason, changes in our water usage habits are imperative to avert future crises.

In many sectors of industry, government bodies have felt it necessary to step in and establish guidelines to regulate the use of resources. The model plumbing code is no exception. We have always have been accustomed to dealing with regulations that dictate design, function, and installation practices. However, regulations establishing maximum water consumption and flow rates are very recent considerations. Today in many parts of the country, spurred by shortages of potable water or inadequate sewage treatment facilities, model plumbing codes and local authorities have initiated water-saving regulations which specifically mandate the installation of water-saving plumbing fixtures and fittings in all new construction and replacement work. When these regulations were first enacted, the plumbing manufacturers were totally unprepared. Any effort to sell the idea of water conservation previously had been met with indifference. Until this point, water was plentiful and utility costs for water and sewage were nominal. For the most part, there was little to motivate either the public or industry to become excited or concerned about water-saving. The situation might well be compared to that of auto safety in the mid-1950's. There was an auto industry effort at that time to introduce safety features on automobiles, but the idea met with either little or no acceptance. It was not until nearly a decade later that the clamor of consumer advocates triggered government regulations enforcing auto safety features. And even then, it was not until gimmicks were installed to force the use of seat belts that they became largely accepted and used.

Today code-writing bodies face the same dilemma. A serious problem has surfaced, and model plumbing codes and local and Federal governments are recognizing the need to establish guidelines and regulations to achieve a solution.

The first attempt to use water-conserving plumbing regulations as a solution was at the Federal level through the establishment of Federal specification WW-P-541/A in 1971. This specification concerned tank-type toilets and stipulated that a class four water conservation toilet shall flush on less than three and one-half gallons of water. At that time, standard toilet consumption ranged between five and seven gallons per flush; so this figure, while not unreasonable, trimmed the allowable consumption nearly in half. This regulation, although it affected only Federally funded projects, accomplished two important things: first, it provided model code groups and local municipalities with a guideline for code regulations; second, it provided a target for plumbing fixture manufacturers.

Model plumbing code requirements pertain to three basic areas where water-conserving appliances may be installed: at the faucet, in the toilet, and in the shower head. These appliances are known as flow restrictors and flow controllers.

Water-saving devices can be located at several points in the piping system of a household such as in the cold water supply line to the house, or in each hot and cold water line leading to each fitting or in the discharge of the fitting (i.e., in the faucet spout or the shower head itself). There are several advantages to installing flow controllers or restrictors at the discharge point. Devices installed at this point can be more readily replaced or cleaned. In addition, it is less costly to retrofit an existing plumbing system by using devices at the discharge end than to install devices in the pressure side of the system. Further, where code requirements call for fittings with maximum flow rates, it is easier for code enforcement officials to check the installation of fittings for compliance with codes rather than to check other methods of flow control. Finally, if flow controllers are installed separately in the hot and cold water lines, it would be necessary to reduce the flow allowed through the hot water line and separately through the cold water line substantially below the total flow allowed, in order to control the maximum flow of a mixed discharge of hot and cold water. This would, of course, mean that when only cold water or hot water is desired, the flow in this case might be unacceptably low. As a result, there has been a significant trend to install the flow control device in the faucet, typically in the aerator on the end of the spout and in the shower head, or in an adaptor unit mounted directly upstream of the shower head.

Performance-oriented model plumbing codes require flow reduction and control and leave the "where-to-put-it" to the designers.

In the Chicago area, Elmhurst in 1976 made a change and instituted an excess facilities water rate to distribute the cost of excess facilities (supply and storage capacity) to the users who were responsible for increased summer demands. Elmhurst felt that the excess facilities rate better relates charges for water to the cost of production as well as providing an incentive for water conservation.

Elmhurst modified its plumbing code to require that all new plumbing installations and replacement plumbing fixtures comply with the following maximum standards:

- Toilet, tank-type: 3.5 gallons per flush
- Toilet, flush-o-meter: three gallons per flush
- Urinal, tank-type: three gallons per flush
- Urinal, flush-o-meter: three gallons per flush
- Shower head: four gallons per minute (gpm)
- Lavatory sink faucet: four gpm maximum flow, with both hot and cold water supply fully open

Since these changes would have a long-term effect and Elmhurst had a short-term water reduction goal, a program was developed to retrofit existing toilets and shower heads with devices that would cut consumption.

Field tests have established that conventional toilets can be retrofitted with volume-reducing or flush-control devices which may reduce water consumption by up to two and one-half gallons per flush. These devices include such things as plastic bottles and displacement dams that can be placed in the flush tank to reduce water volume, while maintaining the same static head and initial velocity of water into the toilet bowl.

Retrofit in Elmhurst was done in conjunction with the public education program. The city council passed a resolution requiring that all toilets, where technically feasible, be retrofitted with displacement dams by January 1, 1978.

In July, August, and September of 1977, the city delivered to each home a set of displacement dams. Where the resident was home, an offer was made to install the dams. Where individuals were not home, the displacement dams were hung in a plastic bag on the door knob with a letter of introduction from the mayor, instructions on how to install the device, plus a postage-paid post card to request installation assistance.

The program was successful and cooperation was obtained from nearly every resident.

In the area of residential usage studies, among the more extensive work that has been undertaken is that of the Washington Suburban Sanitary Commission (WSSC). The multi-faceted aspect of the problem was recognized and attacked by the landmark efforts of the WSSC when it was faced with the twofold problem of a potential water supply shortage and a State board of health sewer moratorium due to lack of treatment capacity in local sewage treatment facilities.

WSSC is a State-chartered, bi-county public utility which provides water and sewer service for over 1.2 million individuals living in a 1,000 square-mile section of suburban Maryland--Montgomery and Prince George's Counties. The area gets its water from two sources: the Potomac and Patuxent Rivers. There is little hope of expanding the area's water supply due to the limited natural flow available in the two rivers. The area's sewage facilities were found inadequate to handle existing sewage flows; they were discharging inadequately treated sewage into local streams.

This situation is a classic case. It is rare that a community cannot solve at least part of its problem by developing untapped water sources if the problem is one of inadequate water supply, or by building additional sewage treatment facilities if the problem is created by inadequate treatment facilities. The WSSC could do neither. Some attempt at solving the problem created by existing construction was imperative.

The result was a massive program of consumer education and experimentation. Studies were made of unique water-conserving devices, a consumer education program was implemented,and plumbing codes were revised to incorporate water-saving fixtures in all installations. While not all of the findings were conclusive, it became evident that a program of consumer education is imperative and the use of water-saving plumbing fixtures and other devices must eventually be mandatory if water-and sewer-related problems are going to be controlled or eliminated.

The studies involved a combination of objectives. Their purpose was primarily to observe the effectiveness of a variety of approaches to reducing water usage within the residential areas serviced by the WSSC. A secondary objective of the Commission's programs was the analysis of consumer habits with regard to the use of water in the home. The initial program, called the Cabin John Drainage Basin Project, was begun to evaluate the effectiveness of several commercially available water-saving devices. The Cabin John area was selected because it was a source of exceptionally high volumes of waste flows. The project involved the installation of four types of insert devices in the toilets of some 1,000 single-family homes and the installation of 3 gpm flow controls in the showers of an additional 25 homes.

An analysis of water use for the Cabin John Drainage Basin for the 11-year period of 1965 through 1975 was conducted to determine the trend of water use in this area before and after the Cabin John project was initiated in the summer of 1972. A significant decrease in water consumption was observed in the four-year period of the conservation program, despite numerous problems with some of the devices.

Other programs that were conducted included a bottle kit distribution and shower flow control device distributions. All of these programs were augmented with an intensive and comprehensive public awareness program.

The code requirements affecting toilets and shower heads initiated by the WSSC were among the first of many to be enacted throughout the country.

We exert a concentrated effort to produce vast amounts of quality-treated water, yet we pay insufficient attention to protecting the quality of water after it leaves the plant. Before presenting the case for removal of cross-connections from the public water distribution systems, a definition of terms may be helpful. A cross-connection is defined as

> any physical connection or arrangement between two otherwise separate piping systems, one of which contains potable water and the other, either water of unknown or questionable safety, or steam, gas, or other chemical whereby there may be a flow from one system to the other, the direction of flow depending on the pressure differential between the two systems.

This definition included both backflow and back-siphonage. Backflow can be defined as the "flow of water, other liquids, mixtures, or substances into distributing pipes of a potable supply of water from any unintended source or sources," while back-siphonage is the "flowing back of used, contaminated, or polluted water from a plumbing fixture, vessel, or other sources into a potable water supply pipe due to a negative pressure in such pipe." We now can take a closer look at the implications of these situations.

Think about it for a minute or two. How many hoses have you seen laying in wastewater below a fixture's spill line when the same hose is connected to your potable water supply line? How about the laundry tray in your home, or your neighbor's? Or perhaps in a bathtub on the sixth floor of an apartment building? What about the chemical plating plant on the other side of town, with all its submerged inlets in plating tanks? Or how about the ballcock in your toilet tank?

Many dangerous cross-connections are simply accidental, or result from an unknowing attempt to "cut corners" in piping installations. Yet ignorance of their potential effects on public health can have disastrous repercussions.

It is apparent that we must provide additional protection for our public water supply systems. Model plumbing codes have cross-connection control requirements. States, communities, and water utilities have developed comprehensive control programs for the elimination and prevention of all cross-connections which state that:

- a schedule is required for inspection and reinspection of all water utility users' premises for possible cross-connections. The periodic reinspections should be used to ascertian whether or not safe air gaps or required protective devices are installed and in working order.

- a description of methods and devices used to protect the public water supply should be made available. These should be approved by the local authority so charged with the responsibility.

- all secondary water supply systems should be property identified and marked so in-plant mistakes cannot be made. All segments of the system should be traceable. If not, it is necessary to protect the system at the service connection in a manner acceptable by the local authority responsible.

- laws and ordinances with teeth in them are needed to enforce a comprehensive cross-connection control program, with stiff penalties for continued violations.

The side effect of proper conservation of water is the conservation of energy.

Who uses the water which we are speaking about here today at this conference? A report showed that electric utilities use 45 percent; agriculture, 34 percent; industry, 13 percent; commercial use, 4 percent; and residential, 4 percent. Certainly a policy must be set for the large consumers of this water. Plumbing codes regulate approximately 21 percent of the water being consumed; the balance of 79 percent is in an area where codes have little or no effect.

It is my belief that flow control and water-saving devices should be standardized throughout the country to help manufacturers avoid problems of many different regulations. This would, I believe, reduce the cost of production of these devices and secondly, would reduce stocking and delivery confusion, and bring about a greater uniformity among model plumbing codes.

Are we really running out of fresh water and the capacity to properly treat sewage? Yes we are! The model plumbing codes are awaiting the opportunity and have the ability to make a major contribution to the efforts of water conservation and use. However, effective communication will be a key to success of any water conservation effort.

It is a complex problem, augmented by many factors. Intelligent planning for the future necessitates an accurate understanding of existing usage.

It is our belief that the water-related problems we face are greater than our country's energy problems.

Conservation Elements in Areawide Planning

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As Chief of the Program Development Branch of the Water Planning Division at the U.S. Environmental Protection Agency, I am pleased to have the opportunity to speak on the role of water conservation in the Water Quality Management (WQM) program. During the past few years the importance and the complexity of the relationship between water quality and water quantity has become increasingly apparent. We are becoming more aware that water quality and water quantity cannot be managed each in a vacuum without regard to their inherent interrelationships. In considering water quality/quantity relationships, water conservation emerges as a significant concern. Water conservation can ensure that water of sufficient quantity and quality is available for beneficial uses such as irrigation, fish and wildlife habitat, recreation, and drinking. Because these uses depend on sufficient quantities of water of sufficient quality, water conservation should be addressed by both water quality and water resource agencies.

The WQM program can play a major role in the water conservation effort. WQM provides the framework for solving a variety of water pollution problems on a coordinated and comprehensive basis. EPA allows State and areawide planning agencies considerable flexibility in identifying their priorities for water pollution control. WQM planning agencies deciding that water shortages may be impairing water quality may perform a detailed assessment of the interrelationships of water quality and quantity and then develop solutions through WQM plans. In the future, EPA will be actively encouraging planning agencies in water-short areas to address water conservation in their WQM programs. There is little doubt that water conservation planning and implementation, when linked with the improvement of water quality, is eligible for EPA grants under Sections 208 and 106 of the Clean Water Act.

To step back a bit, it seems necessary to explain more fully the roles that EPA and, specifically, WQM can expect to play in addressing water conservation. EPA is mandated by the Clean Water Act to protect the quality of the nation's waters. There is little mention of water quantity in the Act. One of the few places that quantity is mentioned in the Act is Section 101 (g):

> It is the policy of Congress that the authority of each State to allocate quantities

> of water within its jurisdiction shall not be superseded, abrogated or otherwise impaired by this Act. It is the further policy of Congress that nothing in this Act shall be construed to supersede or abrogate rights to quantities of water which have been established by any State. Federal agencies shall cooperate with State and local agencies to develop comprehensive solutions to prevent, reduce and eliminate pollution in concert with programs for managing water resources.

This provides a direct legal basis for analysis of the relationship of quantity to quality. On the other hand, a significant but less direct authority for action is provided by Sections 106 and 208 of the Clean Water Act. If water quantity affects water quality and consequently the attainment and maintenance of water quality standards, water conservation activity by WQM planning agencies is legally justified.

The relationship of water quality and quantity is significant for both surface and ground water. The maintenance of adequate instream flows is important to facilitate the attainment and maintenance of water quality standards which provide for a variety of beneficial uses such as recreation and fish and wildlife habitat. Excessive ground water withdrawals often can lead directly to the water quality problems of land subsidence (which can permanently damage the aquifer) and saline intrusion.

There are many situations where water quality and water quantity are closely related. In these instances, any attempt to address water quality affects water quantity and vice versa. Some water quality protection practices positively affect quantity. For example, management practices to protect agricultural soil erosion for water quality purposes, also, in most cases, conserve water.

In Wyoming, a project of the Star Valley Soil and Water Conservation District replacing canal diversion surface irrigation systems with pipe diversion sprinkler systems has resulted in both quality and quantity improvements. Reduction of both erosion and leaching of crop nutrients has improved water quality. At the same time, significant water has been conserved. According to a September 1978 report titled "Irrigation Water Use and Management" prepared by an EPA, Agriculture, and Interior Task Force on Irrigation Efficiencies, the piping has improved conveyance efficiency from 60 percent to 100 percent, and the sprinklers have improved irrigation efficiency from 15 percent to 65 percent. Because of these water savings, instream flows have been increased and can now be maintained in segments of the stream that were previously dry during part of the year.

Another example of irrigation improvements is the Wellton-Mohawk Irrigation District project in Arizona. Again, according to the Task Force report, similar onfarm irrigation improvement techniques are anticipated to

> increase average onfarm irrigation efficiency in the district from 56 to an estimated 72 percent and reduce drainage flow by an estimated 78,000 acre-feet per year, and eliminate salt loading of 500,000 tons of salt per year. With implementation, a salt balance will be obtained in the Wellton-Mohawk by about 1990 and the irrigation district will not be adding to the salt load of the Colorado River.

Inadequate or mismanaged water resources can often adversely affect water quality. Lower flows can lead to increased concentrations of pollutants, which can lead to violations of water quality standards. An example of mismanagement of water quantity adversely affecting quality can be seen in coastal areas where ground water is drafted beyond the safe yield of the aquifer, causing salt water intrusion into the fresh water aquifer. In these cases, improved management of the ground water supply would solve the salinity problem. Another example demonstrating this interrelationship would be a stream where a minimum instream flow cannot be maintained due to overappropriation of the water. Overappropriation can result in at least three quality-related problems which may result in violation of water quality standards:

- reduced flows lessening the dilution (by increasing concentrations) of pollutants from point and nonpoint sources
- increased water temperatures occurring as a result of reduced flows and decreased depths
- reduced flows possibly resulting in increased salinity.

Another related issue is the inadequate quantity of a designated quality of water to satisfy a beneficial use. Specific beneficial uses such as irrigated agriculture, drinking water, and industrial cooling water may have different water quality requirements. Although there may exist a sufficient supply of water, the necessary quantity of a specified quality of water may not be available. Examples of this situation include major Eastern rivers such as the lower Mississippi or the Potomac, where drinking water has been designated as a beneficial use. In these situations, the quality is insufficient, although the quantity is plentiful. Other examples are those portions of the Great Lakes with an insufficient supply of water of sufficient quality to support fishery habitat.

An extreme case for purposes of this discussion would be an inadequate or decreasing supply of water to support any beneficial uses. Such a situation could occur where an area is supplied by a sole source aquifer which is being gradually but permanently depleted. The Ogalala formation serving the Texas High Plains is an example. In such a case, the depletion of a water supply without appropriate management can eventually preclude all beneficial uses.

Through the kinds of interrelationships just discussed, EPA derives its basis for action. The vehicle for action becomes the next issue. President Carter's water conservation directive of July 1978 to EPA and other Federal agencies requires that disincentives to conservation be removed and incentives be included in grant and loan programs. At EPA much of this effort has been focused on the Construction Grants program for wastewater treatment facilities. EPA also has defined a need for a more comprehensive, coordinating approach to address water quality/water quantity interrelationships. The Water Quality Management program has logically become one vehicle for this coordinating approach.

The WQM program is an umbrella program coordinating water pollution abatement activities funded under several sections of the Clean Water Act. Under it, States and areawide planning agencies designated by governors receive grants from EPA for the development of water quality management plans to abate water pollution in order to achieve the goals of the Clean Water Act. Among those goals is water suitable for swimming, fishing, and protection of wildlife by 1983, where attainable. Participating agencies receive grants (up to 75 percent under Section 208) to conduct water quality assessments; identify water quality and source control problems and priorities; and to determine effective point and nonpoint source controls to be implemented by designated State, areawide, and local agencies. Plans must provide for the development of institutional processes, including fiscal and management structures, to make and implement coordinated State and areawide water quality management decisions. At a minimum, award of wastewater treatment plant construction grants and issuance of discharge permits must be consistent with approved WQM plans.

To be effective, this program must comprehensively address all aspects of water quality issues, including conjunctive surface and ground water management and the interrelationships between water resources and water quality.

Beginning with promulgation of the revised WQM regulations in January 1979, consideration of water resource and quality interrelationships and water conservation will be explicitly recognized as part of the WQM process. These issues are in fact already being addressed in several WQM plans in water-short areas. One of the seven elements of the Association of Bay Area Governments (ABAG) plan funded by Section 208 is a regional water conservation, reuse, and supply study. The approach of ABAG is to inspect the area's total water supply for the purpose of making the most efficient use of its waters.

Even before the President announced his new national water resources policy and issued a water conservation directive to EPA, the WQM program, in developing revised regulations, was encouraging the consideration of water conservation. In reponse to the Presidential directive, we are giving more thought to the issue and are examining several alternate regulatory approaches.

The first option is to proceed with our proposed regulations as presently written. Water conservation needs must be considered in determining municipal and industrial wastewater treatment facilities needs for a 20-year period [40 CFR 35.1519-6(d)]. Thus, a planning agency is given the authority to incorporate water conservation needs into portions of its plan influencing the construction of publicly owned treatment works (POTWs) or the treatment of industrial pollutants. In the case of the POTWs, a plan could determine the degree to which a water shortage must reduce the capacity of any future facilities. In the case of industrial waste treatment, a plan could require the inclusion of specific water-conserving conditions in National Pollution Discharge Elimination System (NPDES) permits. Or a plan could influence industrial dischargers through methods other than the permit system, such as through water metering and pricing practices.

A second option is to emphasize water conservation further by including water conservation in the problem assessment section of the regulations and by adding a new water conservation program area, which all plans must eventually address. An advantage of this approach is that EPA would be clearly encouraging the consideration of water conservation in all aspects of the WQM program, including the control of nonpoint source pollution. In the case of Best Management Practices (BMPs) for agriculture and silviculture, BMPs already have the effect of conserving water by increasing infiltration into the water table. However, much could be done in developing BMPs for irrigated agriculture where, in many cases, much more water is consumed than is necessary for crop production.

A third option is to emphasize water conservation even more strongly than other program areas addressed by WQM. (The second option places water conservation at a level of importance equal to other program areas such as urban storm water and residual waste control.) This emphasis could be achieved by requiring WQM problem assessments to examine the need for water conservation within a specified period of time to improve water quality. The requirement could be structured through a certification process. A detailed water conservation problem assessment and subsequent plan element are not required if the planning agency certifies that a water conservation problem does not exist and is not likely to develop within the time frame of the plan. Thus, even if a planning agency is able to make such a certification, the agency has been required to focus, at least briefly, on the issue of water conservation.

Regardless of the extent to which water conservation will be required by the regulations, the WQM program is committed to issuing guidance on water conservation to State and areawide planning agencies. The guidance will begin by demonstrating the importance of examining water conservation by explaining how water quantity affects water quality. Next, the guidance will outline the steps of the problem assessment by which planning agencies can determine whether water quality is impaired by any water shortages. The following analytical step could be the development of a "water quality/quantity budget" for such water-short areas. The "budget" would analyze the demand for water of various qualities as well as the availability of alternative water sources. Such an analysis would further focus the attention of the planning agencies on problems that a water conservation plan might address.

Guidance on the content of a water conservation plan will point out a number of opportunities available to planning agencies to conserve water. One way is to ensure that any POTW construction is responsive to water conservation needs. In developing its annual priority list for POTW projects, the State must consider the construction grant needs and priorities set forth in certified WQM plans. The determination by planning agencies of the needs and priorities for POTW construction should reflect any water conservation needs for the planning area. Another action available to planning agencies is to propose water-conserving NPDES permit conditions for industries and POTWs as part of the WQM plan. Once a plan containing such proposed permit conditions is approved, Section 208(e) of the Clean Water Act requires those conditions to be incorporated in NPDES permits. A third major opportunity for water conservation initiative by planning agencies is in the development of BMPs for the control of agriculturally and silviculturally related nonpoint sources of pollution. Although BMPs developed in the past have had a positive water conservation effect, more work can be done in this area, particularly with regard to irrigated agriculture.

Besides explaining to planning agencies how to conduct a water conservation problem assessment and what might be included in a water conservation plan, our guidance will stress some further technical and institutional aspects of developing and implementing water conservation programs. We will furnish planning agencies with information on the costs and benefits of such initiatives as the imposition of water metering, alternate water pricing schedules, water conveyance system rehabilitation to reduce losses, design criteria to minimize new losses, and fixture and appliance standards for new structures and retrofitting. In the institutional area we will stress the importance of coordination between the planning agencies and the State water resource agencies. For the water conservation initiatives to be successful, it is essential in many cases for the planning agencies to have the full cooperation of the water resource agencies. Finally, our guidance can help planning agencies by providing them with case histories describing previous efforts at planning for and implementing water conservation.

Finally, I would like to draw your attention to how the State/EPA Agreement, a relatively new management concept at EPA, will influence the role of water conservation in the WQM program.

The WQM program will be part of EPA's recent efforts to integrate the planning, implementing, and managing of environmental problems at the regional and State levels through the mechanism of the State/EPA Agreement. In Fiscal Year 1980 water supply, solid waste, and water pollution control programs will be integrated. The purpose is to coordinate environmental planning and management, rather than attempting to solve interrelated environmental problems separately on a program-by-program basis.

Each State and corresponding EPA Region will negotiate a State/EPA Agreement to include statements of environmental problems and objectives based on State problem assessments and strategies. Work programs will be identified and implemented based on prioritization of needs, responsibilities, and allocation of funds.

Certainly water shortage is one problem area which should be assessed by each State. Whether or not it becomes a high or low priority will depend upon each State's assessment of all the environmental problems falling under the Agreement. In many Western States, for example, water quantity poses a greater problem than in areas of relative water abundance. This high priority would be reflected in State/EPA Agreements for such States. If the quantity of water is identified as a priority under the Agreement, then the State will have a means by which to coordinate and integrate the programs pertaining to, and the sources of funding available for, the planning and management of water conservation.

Conservation and the Safe Drinking Water Act

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THE SAFE DRINKING WATER ACT (P.L. 93-523)

The story of P.L. 93-523 begins with the National Community Water Supply Study of 1969-70 which indicated that, while most Americans receive drinking water of adequate quality, many do not. The study was conducted at a time when parameters of concern were inorganic chemicals and bacteria. Quality deficiencies were shown to be related to major deficiencies in State supervisory programs, inadequate local monitoring, poorly trained operators, and antiquated treatment and distribution facilities evidencing potential sanitary defects.

The study scope included:

- the State of Vermont plus eight Standard Metropolitan Statistical Areas (SMSA)
- eighteen million people
- initially 450 systems based on a 1963 Inventory of Public Water Supply Systems
- sanitary surveys; i.e., field inspections of all systems within each SMSA
- complete chemical and bacterial analyses for all constituents then included in 1962 U.S. Public Health Service Drinking Water Standards.

The results of the study include the following eye-opening results:

- 85 percent of the systems were analyzing insufficient numbers of bacterial samples
- 69 percent of the systems did not even analyze one-half of the recommended bacterial samples
- 79 percent were not inspected by the county or State in the year prior to the study
- 450 expected systems grew to 969 systems
- 50 percent of the operators could not remember ever being inspected by the State or county inspectors
- 77 percent of the operators were not trained in bacteriology
- 46 percent of the operators were not trained in chemistry
- 56 percent of the physical plants evidenced inadequate disinfection capacity or inadequate clarification capacity

- 36 percent of 2600 samples exceeded recommended maximum contaminant levels.

The above results explain the bottom line:

- bacteria: 9 percent exceeded recommended maximum contaminant levels
- chemical: 30 percent exceeded recommended maximum contaminant levels.

Moreover, a limited sampling showed that 11 percent of 90 systems exceeded a broad, semi-qualitative index of synthetic chemical pollution.

During the early 1970's, Congress became interested in drinking water quality. At the same time, years of research culminated in the introduction of new analytical procedures with which to begin to identify and quantify specific volatile organic compounds. By 1975, the U.S. Environmental Protection Agency's National Organics Reconnaissance Survey confirmed the forecasts of knowledgeable professionals: trace concentrations of potentially toxic organic chemicals were identified in many surface sources and in occasional ground water sources. In addition, numerous synthetic organic chemicals, including potential carcinogens, were found in "finished" municipal drinking water systems. This survey also demonstrated, on a national scale, that the addition of the chemical disinfectant chlorine during the treatment process leads to the formation of the carcinogen chloroform.

The National Community Water Supply Study and organic chemical studies led to the passage of the Safe Drinking Water Act (SDWA), P.L. 93-523, on December 17, 1974. The Act provides a statutory base for national drinking water standards, both maximum contaminant levels (MCL's) and treatment regulations, public notification when the regulations are violated, and additional financial resources to States for water supply regulatory programs. The Act also provides for a program to protect ground water aquifers now being used or with potential for use as a source of drinking water.

Other authorities provided by the Act and particularly relevant to the conservation of water supplies and wastewater flows include research, development (including reuse demonstration), technical assistance, and training. Moreover, recent amendments call for a study of the adequacy of current and future water supplies, a study which is being conducted in concert with a provision of the Clean Water Act, Section 516(e) of P.L. 95-217, which is aimed at encouraging coordinated water supply and wastewater planning at the local level.

THE INTERIM PRIMARY DRINKING WATER REGULATIONS

To rectify the deficiencies identified by the Community Water Supply Study and in support of the principle that the community water treatment system provides a last line of defense for community health, the National Interim Primary Drinking Water Regulations (IPDWR's) were promulgated on December 24, 1975 and July 9, 1976 and became effective on June 24, 1977.

These regulations were based on the Public Health Service Drinking Water Standards of 1962, as revised by an ad hoc committee in 1972 and with the advice of the statutory National Drinking Water Advisory Council. The regulations specify MCL's and monitoring requirements for microbiological contaminants (coliform bacteria), 10 inorganic chemicals, six organic chemicals (pesticides), radionuclides,and turbidity. Secondary drinking water regulations were proposed by EPA on March 31, 1977.

The primary regulations are devoted to constituents affecting the health of consumers, while secondary regulations include those constituents which consider the aesthetic qualities of drinking water. The primary regulations are applicable to all public water systems which regularly serve 15 service connections or 25 people and are enforceable by States which have accepted primacy. In the absence of state primary enforcement, however, EPA is required to enforce the IPDW Regulations. Secondary regulations, which will be promulgated this fall, are not federally enforceable and are intended only as guidelines for the States.

To be included in the regulations as an MCL, a parameter must be susceptible to simple analysis at the operating level. This recognizes that the Act intends that monitoring will be routinely accomplished by the local water system rather than by the State or EPA. Where routine monitoring is not possible, EPA has authority to issue treatment regulations.

STATE PRIMARY ENFORCEMENT AUTHORITY

Consistent with the letter and the spirit of the law, the House Report, and EPA's implementation philosophy, "One Step at a Time," States are moving towards primacy.

Once a State establishes that it can mount and implement an effective program to supervise all public systems within the State, including enforcement under State law, the Act provides that a State gains primary enforcement authority and is eligible for a state program grant.

Since April of 1977, 40 States have sought and secured legislative change at the state level and updated their regulations to a point where they are equivalent to or more stringent than the Federal IPDW Regulations. An additional five States have adopted the needed legislative authority and are revising their regulations and preparing their primacy application.

Most of the 13 other States and territories are moving toward primacy. Thus, with but a few notable exceptions (Oregon, Indiana, and Pennsylvania) both the primacy States and those making substantial progress towards primacy shared $20.4 million in program grants last year, and consistent with President Carter's budget, will receive $26 million in Fiscal Year 1979.

By comparison with 1975, when we estimated that the States were applying $16 million and employing 700 people to supervise the nation's 40,000 community systems, we now estimate that state programs will grow to $42 million and 1,200 people in the near future. Thus, the legal, institutional, and technical capacity to address the numerous deficiencies categorized by the National Community Water Supply Study, in an era when bacteria and inorganic chemicals were the primary cause for concern, is largely in place. The capacity to provide surveillance, technical assistance, and training is improving. Moreover, the ability of the States to enforce drinking water regulations has been substantially improved.

THE NEXT STEP

"One Step At A Time" also means that we must move forward to address yet additional threats to the over 200 million drinking water users. EPA's multifaceted approach will continue to tighten up on sources of pollution (witness the recent reestablishment in the final minutes of the 95th Congress of Section 311 of P.L. 95-217), make an effort to tighten up on industrial pretreatment, and to prevent potential pollution of the nation's ground water aquifers. Moreover, EPA is now moving to explicitly address synthetic organic chemicals in drinking water.

On February 9, 1978, EPA acknowledged the synthetic organic chemical threat in drinking water and published a proposal in the Federal Register to further amend the IPDW Regulations. In addition to chloroform, which has been declared a carcinogen by the National Cancer Institute and is formed primarily in drinking water systems employing chlorination, the preamble to the February 9, 1978 statement calls attention to the fact that over 700 specific synthetic compounds have been identified in drinking water systems, including 22 chemicals which are known or potential carcinogens according to the June, 1977 report of the National Academy of Sciences (NAS). Moreover, since the NAS report, two additional chemicals have been added to the ever-growing list of known and potential carcinogens. The list is likely to grow from year to year.

The proposed amendments to the IPDW Regulations consist of two parts:

- An MCL for total trihalomethanes (THM) including chloroform is proposed. The proposal would require all communities with populations between 10,000 and 75,000 to begin monitoring within six months of promulgation and to report results to either the State or EPA, whichever has primacy. Cities of 75,000 or more, which account for over 52 percent of the national population, would be required to begin monitoring within three months and meet the MCL of 100 parts per billion (ppb) within 18 months.

  Neglecting the 60 systems that purchase water from larger systems and 18 systems that do not chlorinate, EPA estimates that 312 systems will be impacted by these regulations. Most of the impacted systems do not exceed the MCL or will change the disinfection point or otherwise "tune-up" the treatment process to meet the proposed MCL. For such systems, the cost impact will be negligible.

  On the other hand, it is estimated that 43 cities now exceed the MCL by a substantial margin and may find it necessary to modify existing treatment trains to add absorbents. The total cost of the THM proposal is $268 to $335 million, with continuing operation and maintenance costs estimated at $30 to $38 million per year.

- The February 9 proposal provides for treatment with granular activated carbon (GAC) or equivalent for all systems with populations of over 75,000 that are vulnerable to synthetic organic chemical pollution.

  Here the burden of proof will be on the systems. In those instances where a sanitary survey and chemical monitoring document little upstream threat, either the primacy states or EPA will issue a variance to the treatment requirement. However, it is estimated that about 50 systems will find it necessary to install GAC within 3-1/2 years after promulgation at an estimated cost of between $348 and $496 million. Operation and maintenance will account for $32 to $48 million, and annual revenue requirements will be $67 to $98 million.

  In terms of cost for the individual family, a group of three residing in a community of 75,000 to 100,000 will have to spend $18.50 to $26.10 more each year for its water bill. An equivalent family in a community of 100,000 to one million people will have to pay $11.90 to $17.00 additional each year, and a family of three residing in a district serving more than one million will incur a bill increase of $7.00 to $12.70 each year.

These proposals respond to provisions of the SDWA as addressed by the House of Representatives Report of July 10,1974, which was upheld by the U.S. Court of Appeals for the District of Columbia (EDF vs Train). The court noted that waiting for risks to be fully evaluated would be contrary to the intent of the Act.

The House Report, page 10 states:

> Primary regulations must specify contaminants which in the judgement of the Administrator may have an adverse effect on the health of persons when found in drinking water. The words used by the Committee were carefully chosen. Because of the essentially preventive purpose of the legislation, the vast number of contaminants which may need to be regulated, and the limited amount of knowledge presently available on the health of various contaminants in drinking water. the Committee did not intend to require conclusive proof that any contaminant will cause adverse health effects as a condition for regulation of a suspected contaminant. Rather, all that is required is that the Administrator make a reasoned and plausible judgement that a contaminant need not have the adverse effect directly in order for the Administrator to regulate it as a primary contaminant. If it is a precursor to a contaminant which may have such effect or if it may contribute to such effect, the contaminant should be controlled under primary conditions.

The proposed regulations have generated considerable public comment and new information. In order to present new information, and to encourage continuing public comment on the proposed regulations, a Supplemental Notice on the regulations was published in the Federal Register on July 6, 1978. At that time the comment period was extended an additional month, until September 1, 1978.

The comment period is now closed. Approximately 595 comments have been received. In addition, the testimony of several hundred individuals was recorded during the eight public hearings on the proposed regulations. EPA is now evaluating all comments, testimony, and information which has become available and anticipates final promulgation in the spring of 1979.

AND YET ANOTHER STEP

Waiting in the wings is yet another proposed regulation to address the pollution of the nation's ground water aquifers. In addition to the broad environmental concern relative to such pollution, ground water currently serves as a source of supply for one-half of the nation's population. Consistent with the SDWA, a regulation to control potential pollution of drinking water aquifers was proposed last year. Numerous public comments have been critically reviewed and additional legal and economic analyses are now nearing completion.

As part of a revised approach to the control of ground water pollution, a strategy is being developed to integrate a host of legislative authorities which are available to regulate the control of waste disposal practices and to regulate the control of specific substances.

Authorities for the control of waste disposal practices include principally Section 1421 of the SDWA to regulate the injection of fluids into wells for disposal, extraction, storage or recharge, and Section 4004 of the Resource Conservation and Recovery Act (P.L. 94-580) to regulate the surface disposal of solid wastes.

Pits, ponds, and lagoons, a major category of waste disposal practices, is the subject of a $5 million study to be performed by the States. The States are being asked to:

- inventory these practices
- assess the threat
- identify existing State efforts
- identify a Federal role supportive of State control efforts.

In view of a number of legal issues, a final decision on federal regulatory strategy for this category, or perhaps additional legislation to address problems, will be made after the States complete the assessment.

In the meantime, regulations to control injection practices now subject to the SDWA were printed in the fall of 1978. Solid waste disposal practices are the subject of regulations proposed on February 6, 1978, with final promulgation expected in the immediate future.

Other vehicles for controlling or potentially controlling "practices" include Sections 208,303 (comprehensive water quality plans) and 516 (e) of the Clean Water Act of 1977 (P.L. 95-217) and Section 1424 (e) (the sole source aquifer provision) of the SDWA.

The control of substances will involve an equally potent array of existing legislative authority in cases where a specific substance has been deemed harmful to human health or the environment. Here EPA has been provided with authority to mandate control of production, sale, use, and disposal for chemicals of concern. Authorities relevant to ground water protection include:

- the Toxic Substances Control Act (P.L. 94-469) to regulate the introduction of new chemicals into commerce
- The Resource Conservation and Control Act and the Clean Water Act to control hazardous substances which might be applied to the ground or to the subsurface.

CONSERVATION

From the earliest days of this nation, water has been a major determinant in the initial location and eventual growth of our original settlements and milltowns which now number about 40,000 communities. Commercial centers sprang up on our coastlines and along our major rivers due to ease of transportation as well as a readily available source of water supply for industry, agriculture, and community uses.

As the 1800's were drawing to a close, major metropolitan centers evolved, dams were built, and water was transported over ever-increasing distances through aqueducts to meet the seemingly ever-increasing demands of towns, which became cities, which are now major metropolitan areas (e.g., Boston, New York, San Francisco, Los Angeles).

During this period, few appeared to be concerned with the quality of water supply. What was important was the assurance of quantities sufficient to meet the growth model of the city, town, and nation.

The thought that there will always be more water available to meet "supply requirements" through larger and larger water supply systems and larger and larger waste collection and treatment systems has been seriously questioned only within the last decade. And within the last several years an amalgamation of environmental interests has forcefully established that the nation now needs to seek a new model wherein conservation becomes the ethic wherever technically and economically possible.

The thought that there will always be more water available when needed is one explanation for the fact that the 40-page SDWA included the word "quantity" in only one instance. Paradoxically, this reference expresses concern for the individual homeowner or farmstead user who is dependent upon his own well or cistern for a source of drinking water.

And yet, it should be clearly recognized that the SDWA is one of the most basic conservation statutes available at the Federal level. First and foremost the Act is focused on protecting the health and welfare of that singularly important species--Homo sapiens. Second, the Act provided the first viable means to begin to protect the quality of the nation's tremendous quantitative ground water resources which currently quench the thirst of half the nation's population--with infrequent water treatment required to meet the IPDW Regulations. On these two bases, the SDWA is a major conservation statute with research, development, training, and technical assistance authorities available once new national policy directions are established.

Most of EPA's response to the conservation ethic, as articulated by President Carter and by the Clean Water Act, are presented elsewhere in this conference. One effort, authorized by a recent amendment (Section 1442 (c)) to the SDWA and an EPA decision to launch this study on a fully integrated basis with a new provision, Section 516 (e) of the Clean Water Act, is described below.

EPA's INTEGRATED WATER SUPPLY-WASTEWATER TREATMENT STUDY

In drafting, debating, and enacting the 1977 legislation in both safe drinking water and water pollution control, Congress strongly indicated its concern for availability of sufficient water supplies and for facilitating coordination between water supply and water pollution control activities. The results of these concerns were two specific requirements for EPA reports to Congress.

- The SDWA states that:

> Not later than eighteen months after the date of enactment of this subsection, the Administrator shall submit a report to Congress on the present and projected future availability of an adequate and dependable supply of safe drinking water to meet present and projected future need. Such report shall include an analysis of the future demand for drinking water and other competing uses of water, the availability and use of methods to conserve water or reduce demand, the adequacy of present measures to assure adequate and dependable supplies of safe drinking water, and the problems (financial, legal, or other) which need to be resolved in order to assure the availability of such supplies for the future. Existing information

> and data compiled by the National Water Commission and others shall be utilized to the extent possible.

- The Clean Water Act states that:

> The Administrator, in cooperation with the states, including water pollution control agencies, and other water pollution control planning agencies, and water supply and water resources agencies of the states and the United States shall submit to Congress, within two years of the date of enactment of this Section, a report with recommendations for legislation on a program to require coordination between water supply and wastewater control plans as a condition to grants for construction of treatment works under this Act. No such report shall be submitted except after opportunity for public hearings on such proposed report.

The purpose of the proposed "Water Supply-Wastewater Treatment Coordination Study" is to provide a report which:

- will be submitted to Congress in satisfaction of the above two reporting requirements

- responds to the congressional concerns indicated by the above language, specifically that:

    a) present and future availability of an adequate and dependable supply of safe drinking water be assured in light of other growing demands for water use and possible inadequacies of existing mechanisms for managing both the quantity and quality aspects of the water resource

    b) opportunities to achieve savings through coordination of water supply and water pollution control programs be captured, in particular as they involve Federal grants for constructing wastewater treatment plants

- describes potential administrative and legislative policies to address problems and opportunities identified

- provides a synthesis of available data and other information which is useful for evaluating potential policies and deciding which ones to adopt.

- recommends policies to the extent justified by available data.

Examples of important issues which the study is to consider and on which recommendations may be made are:

- conservation of water as a potential means for
  - a) accomodating growing needs with available supplies
  - b) improving water quality
  - c) realizing significant monetary and energy savings in both water supply and wastewater treatment
- the tradeoff between requiring additional wastewater treatment to protect drinking water sources such as major rivers, or requiring sophisticated water supply treatment when water is taken from those sources for drinking use
- reuse of water in terms of
  - a) its potential for satisfying nonpotable water supply needs and thus releasing other waters for drinking use
  - b) its economic and energy advantages as a source of needed increases in supply
  - c) crucial bottlenecks which must be resolved if reuse is to be accepted
- the adequacy with which ground water sources of drinking water are protected, especially in light of potential increases in
  - a) land treatment
  - b) recharge with wastewater
  - c) injection as a means for disposal.

Studies regarding the above and other issues must be carefully related to imbalances between estimated future water uses and available supplies under various degrees of drought, emerging technologies and changes (e.g., land treatment of wastewater, and increasing emergency and chemical costs), and the practical opportunities for coordination which exist or can be created within water quality and water supply planning.

CONCLUSION

A positive momentum has been established since the SDWA became law.

Basic Federal drinking water quality regulations have been issued governing the bacterial and chemical content of drinking water. Further, substantial progress has been achieved at the State level in establishing the legal and institutional capacity to address deficiencies identified in past studies when the principal concerns were bacterial and inorganic chemicals in the nation's drinking water.

A new phase has begun. Proposals to control synthetic organic chemicals in particular and to prevent ground water pollution in general are now moving forward.

The future role of the SDWA relative to evolving a national conservation program is now under development. Contributing to the formulation process will be recommendations developed through a report to Congress responding to Section 1442 (c) of the SDWA and Section 516 (e) of the Clean Water Act.

Collectively, the basic regulations, the new regulatory proposals, and the ultimate recommendations issuing from recently initiated studies will hasten this nation towards the goal of a safe and adequate supply of drinking water for all Americans on contemporary criteria involving economic and technological feasibility.

The Conservation Connection: The Clean Water Act of 1977 and EPA's Construction Grants Program

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Here in Chicago, near Lake Michigan, many would find it hard to believe anyone could worry about running out of water. Water has been periodically short in this region, however, due to droughts, and future scarcity of high quality water is not unlikely even here. Much of this northern Illinois area draws its potable water from a single, slowly recharging aquifer, which is being pumped much faster than it is being refilled. In addition, current orders of the Supreme Court strictly limit withdrawals from Lake Michigan for use in this area. And those same Court orders also make reference to the requirement that conservation programs be in place in communities wishing newly to acquire rights to Lake Michigan water. Elsewhere in this conference program, you will be hearing about a conservation program in Elmhurst, Illinois, which now draws its vital water supply from the heavily burdened Galesville sandstone aquifer which flows beneath us here.

Further arguments for conservation, even in the face of apparently plentiful potable water, stem from rapidly increasing costs for energy to pump, purify, and circulate water (and resultant wastewater), greater costs of systems to purify, store, and distribute potable water; and the expenditure required to re-collect, treat, and transport growing amounts of wastewater. Hence, Chicago is a good place to discuss water conservation, despite the appearance of abundance in water supply here. It is, of course, the focus of the entire conference: the protection of a valuable and finite resource!

Federal concern with water began in 1948 in a modest fashion, when the Congress passed legislation to protect water quality. The Construction Grants Program, designed to assist communities to deal with wastewater problems, began in a small way in 1956. A major shift and increase in emphasis came in 1972, with the Federal Water Pollution Control Act (FWPCA) (PL 92-500). The FWPCA of 1972 made the U.S. Environmental Protection Agency (EPA) the national guardian of the country's surface and ground waters. It also greatly expanded the Construction Grants Program. Under the program, the government funds 75 percent or more of eligible costs of community treatment plants, with the community paying the remaining 25 percent, or slightly less in some cases.

As many of you are aware, this program is the largest public construction program in the country. EPA has obligated some $19 billion in grants since 1972 and expects to obligate upwards of an additional $25 billion this year and in the next four fiscal years.

In December 1977, about a year ago, the Congress passed the Clean Water Act (PL 95-217), which comprised amendments to the 1972 legislation (PL 92-500), and put a new emphasis on conservation. Among the new provisions are requirements that communities requesting Federal grants for wastewater treatment works must show that conservation measures have been examined for cost-effectiveness in resolving wastewater problems. In addition, new emphasis is placed upon encouragement of new technologies to complement and in some cases supplant conventional treatment methods. Greater emphasis is placed on support of small systems for areas in which conventional gravity sewers and associated treatment works are excessively expensive.

The passage of the Clean Water Act was followed in June 1978 by additional Administration initiatives. In June 1978, President Carter called for a new policy on water. The new water policy establishes conservation as a cornerstone of Federal water policy, along with a call for generally better management practices for our water resources. In July 1978, the President directed EPA to head a new task force to review the several grant and loan programs involving water resources administered by various government agencies. The President wants to put an end to practices offering disincentives to conservation of water and wants to add, where possible, requirements that communities have conservation programs as conditions for obtaining grants or loans. New conditions are to be applied to projects initiated after September 30, 1979--that is, all projects beginning with fiscal year 1980 (FY 1980). The Construction Grants Program essentially fulfilled the President's new requests on its own in creating operating rules for the program under the Clean Water Act of 1977--new operating regulations which went into effect on September 27, 1978. The task force examining conservation possibilities is to report its findings early in 1979.

The President is expected to make a major statement on rural water and sewer policies early in December 1978. Small communities with dispersed populations often can use small treatment systems which are cheaper and do not make as heavy use of water and other resources. They are often excellent alternatives to big centralized systems. The President's statement will reflect in part the work of a six-agency task force appointed in June 1978 to address rural water and sewer problems. EPA is a member of this task force. The group will, in effect, deliver the Construction Grants Program to rural America. It will do this by helping rural communities to identify their own needs, and by telling them about programs that can help them. Surely everyone knows of small towns where the government is comprised of a part-time mayor and a part-time clerk. EPA is preparing a manual that explains programs in simple terms. The first draft is to be ready soon. We are also cutting down on red tape and shortening project review times.

These new initiatives, taken together, represent a major departure from previous policies on water supply and pollution control. The earlier policies emphasized provision of whatever facilities were necessary to meet demand for water and wastewater treatment. They emphasized the role of the engineer and the construction contractor and assumed that all resource requirements could be met if only we looked far enough ahead and designed carefully. The new initiatives assume that resources are inadequate to meet undisciplined needs in the future. Continual provision of clear water for a balance of uses requires careful marshalling of resources through demand reduction as well as increased supply and treatment. The skills of the social scientist and public affairs specialist must supplement those of the engineer and contractor to achieve this reduction.

EPA published its revised regulations and accompanying cost-effectiveness guidelines on September 27, 1978. Any community that obtains a grant after September 30, 1978 (the end of Fiscal Year 1978), to help it build a wastewater treatment plant or wastewater conveyance will be required to follow the new regulations and guidelines. As you can see, things are happening--and this conference is one example.

An important element of the 1972 and 1977 Water Pollution Control Acts is their emphasis on communicating with the public and including the public in planning as much as possible. The 1977 Act stated that EPA should conduct a national information and educational program on water conservation and flow reduction. This conference is part of that program. Other items are also in progress.

During 1979 we will put out a half million copies of a water conservation booklet. The booklet will be distributed through a supermarket distribution system, and additional copies will be available through EPA headquarters in Washington. The pamphlet gives tips on how to save water in the home--from not running the faucet for rinsing dishes to reducing use of toilets for general waste disposal in addition to their designed uses.

In addition, we will distribute 200,000 copies of a waterwheel device which also will help householders to find ways to save water. The device can be hung in the kitchen and referred to conveniently.

A grant is under way to produce 100 copies of a color videotape that will show conservation as an alternative to continuing wasteful use of our valued water resources and undisciplined continued growth of very expensive processing facilities for both water and wastewater treatment. Local community groups will assist in critiquing the videotape before it is produced in final form. The tape is designed to be used in public broadcasting, by community groups, or in 16mm form where appropriate.

A plan is being completed for purchase and distribution of 200 copies of a prize-winning cartoon film on water conservation suitable for showing in schools, community meetings, or other community affairs. Distribution will be without cost to the viewers.

Participants in this conference have a draft copy of a Directory of Water Conservation Programs in Government. We want your input on this document so we can consider your comments for the final publication. We hope this document will also have wide circulation. In addition, it is expected that we will publish and distribute selected papers from earlier conferences on how to shop efficiently and effectively for a sewage treatment system.

Through cooperative efforts of the EPA environmental laboratory in Ada, Oklahoma, and Oklahoma State University, a slide/tape presentation is being prepared on the topic of land treatment of wastes, including sludge and effluent.

An additional information directive of the 1977 Clean Water Act was its call for a national clearinghouse to collect and distribute information on new and alternative ways to treat waste besides the use of conventional central systems. EPA has set up such a clearinghouse in Cincinnati through the Environmental Research Information Center (ERIC).

The 1972 Water Pollution Control Act requires that communities receiving grants give their citizens a greater say in facility planning and in how user charges are determined. EPA expects to issue new regulations on citizen participation in early 1979, which will substantially increase citizen input into the whole planning process, from the selection of alternative modes of wastewater treatment to be examined to the final proposals for Federal support.

The overall thrust of the Clean Water Act of 1977 and the President's new policy initiatives is that clean water is a valuable commodity that needs to be protected for future use. The new EPA regulations and cost-effectiveness guidelines published in September 1978 reflect this. They stress flow reduction, reuse, recycling, and alternative and innovative technology. The emphasis on demand reduction appears mainly in the guidelines. Their overall aim is to save resources, including water, energy, materials, and money.

A prime goal is to ensure that communities plan treatment systems that are only as big as they need and that are cost-effective now, while still allowing for a reasonable growth rate. The extra capacity in a treatment system which is incorporated for future growth is called reserve capacity. There are numerous cases in which communities have overbuilt their systems. In the extreme, cases exist where the cost of the wastewater treatment system exceeds the entire assessed value of the community which it is designed to serve!

The guidelines require that projections of reserve capacity consider the amount of water that will be saved by flow reduction measures. The population figures used in such projections must be based on those of the U.S. Department of Commerce's Bureau of Economic Analysis. These numbers, which are further desegregated at the State level, are intended to prevent a community from saddling itself with a huge plant it cannot pay for because the expected growth (or hoped-for growth) did not occur. These projections are often controversial, of course, since most towns appear to believe they will grow more than total State and national population growth estimates would support--if all the separate town or community estimates were added together at any point in time.

Besides their emphasis on flow reduction in determining reserve capacity, the guidelines demand that communities consider water conservation in other ways. The facility plan must include a cost-effectiveness analysis for a 20-year period that shows savings in water and costs that could result from water conservation measures. These measures include:

- A community information program on water conservation
- Cost evaluations of the water pricing system
- Installation of water meters
- Fitting existing homes and commerical facilities with water-saving devices such as plastic toilet dams and low-flow showerheads
- Ordinance changes in plumbing and building codes that encourage installing such devices in future buildings or encourage water-conserving design specifications.

Preliminary EPA studies show that potential savings for an existing household that installs water-saving devices run to $54 a year in water and energy costs. These water-saving devices include 3½ gallon/flush toilets, low-flow showerheads, aerated kitchen and lavatory faucets, and water-saving automatic clothes washers and dishwashers. Our figures assume a constant cost for water and energy; expected increases in both water charges and energy costs would strengthen the case for household conservation programs.

The studies show that a new house designed for maximum water conservation might save about $96 a year. There is a potential national savings of $27.7 billion during the period 1978 to 1990 from water conservation--savings in water supply facilities, treatment facilities, sewers, and energy.

Ideally, a savings of 14.6 trillion gallons of potable water is possible during the same years (1978 to 1990), and accrued savings on household energy--gas, oil, and electricity--come to 3 to 4 percent.

One large university saved $100,000 in water, sewerage, and energy bills in a single year by installing low-flow showerheads costing about $15,000. In terms of energy and water savings, the showerhead installation may be the most cost-effective single device available.

The 1977 Clean Water Act and EPA guidelines encourage water conservation by their stress on what we call innovative and alternative technologies. A community that seeks grant funds after September 30, 1978, must show it considered using technology other than conventional, central treatment systems in finding solutions to its pollution problems.

An "alternative" technology is one that has been used and has proved itself, but which is different from conventional gravity sewer and treatment systems. An "innovative" technology is one that has not been used in the way the community proposes to employ it and, hence, may not have proven itself completely. The administration of these features of the law is complex and difficult, since a process may be innovative in one time and place and not in another.

Alternative systems could include land treatment; reuse; recycling; energy recovery; septic tanks with soil absorption fields; septic tanks with add-ons, including mound systems; aerobic units; low-water or no-water toilets; and vacuum and pressure sewers.

These alternative systems can often be much cheaper and just as effective for small communities when they are properly installed and maintained. Grant provisions provide for adequacy in maintenance of non-traditional systems.

EPA guidelines for alternative systems offer special benefits for their installation and use:

- They can cost up to 15 percent more than the most cost-effective conventional system and still be grant-eligible
- Federal shares may equal 85 percent rather than 75 percent of total eligible costs
- A rural State must set aside 4 percent of its allotment for systems that are to be installed in towns of 3,500 population or less
- There is also a two-percent set aside in a State's allotment to pay the extra cost for increasing innovative and alternative project grants from 75 to 85 percent.

The guidelines also address conservation in their requirements for better industrial wastewater control. Industries using municipal sewers are required to pay user fees based upon volume of wastewater and pollutant loading. These fees should discourage industrial users from carelessly discharging and using large volumes of water.

EPA is giving major emphasis to a program calling for pretreatment of toxic substances by industries that discharge into municipal wastewater treatment systems. Often, an industrial firm can better handle a specific toxic material than can a general municipal wastewater treatment system. Further, the costs for pretreatment should encourage water reuse, recycling, and generally reduced potable water inputs, with obvious benefits to municipal wastewater treatment systems.

EPA is working continuously on effluent guidelines, which specify allowable pollution levels for discharged industrial wastewater. Some industries are trying to revise their manufacturing processes so they can reuse water, thereby reducing discharge amounts. The effluent guidelines and user charge systems are intended to encourage such in-process changes.

The Clean Water Act of 1977 and EPA operating regulations for the Act dealing with user fees indirectly encourage conservation of water. All users of systems receiving grant funds must pay charges in proportion to their use of the sewer system. Residential users must be notified of their total sewer service charges, making such costs more visible and raising the consciousness of citizens to the importance of wastewater treatment problems in their own communities.

A number of problems arise, however, when the Construction Grants Program is used as a vehicle for conservation. The municipal sewage agency is that agency subject to EPA regulations concerning grant eligibility and Federal support. That agency does not always have the authority to bring about potable water flow reduction. The regulations issued in late 1978 take account of this situation and do not require action unless those who have the authority agree to them. Quite aside from technological problems involved in pollution abatement programs, this situation provides an example of institutional problems which are not easily solved by engineering techniques. Rather, water and wastewater managers, along with citizens, must work to bring about changes in the values and behavior of persons involved at various stages in the processes associated with providing potable water and properly treating and disposing of wastewater.

A second problem which emerges is that water demand reduction does involve changes in people's habits--providing additional need for and justification of increased public participation in the operation of the Construction Grants Program. In the longer run, conservation practices will succeed only with an informed public's participation and consent.

A third problem for water conservation programming is the uncertainty that at times is associated with flow reduction. With its dependence upon active human participation, flow reduction might be achieved for a period, then lost. A facility minimally designed with flow reduction in mind might be insufficient if flow reduction goals are not achieved over the long run. Where such a situation occurs, EPA will have to take a flexible stance with communities that acted in good faith and assumed that their system would be adequate. It should also be noted that such possibilities underline the necessity for community conviction about conserving water resources on the one hand, and the desirability of passive flow reduction measures (e.g., low-flow showerheads and toilets) on the other.

Long-term financing may provide further problems difficult to resolve. A community might find it has to increase rates to defray debt retirement costs, even though less water is being used,and conservation goals themselves are being met. Such results may place local political leadership in jeopardy. The total long-term costs to the consumer will decrease (demand reduction may reduce future capital outlay needs), but unit costs will go up. This is a complex set of relationships difficult to explain and understand.

A balanced view of the pros and cons of conservation must also take into account the possibility of treatment works malfunctions as a result of lowered water demand. Deposits may accumulate in sewer pipes as a result of reduced flow. When flow reduction exceeds about 30 percent of design flow, wastewater treatment plans may fail to meet design expectations for effluent quality. We do, however, have some experience in these issues which suggests that fears of malfunction may be more imaginary than real in most cases.

In 1977, in five California utility districts where a drought-driven major conservation program was in effect, we found flow reductions ranging from 25 to 60 percent below normal pre-drought levels. Wastewater treatment plants could handle as much as a 30 percent reduction in flow without serious adverse effects on efficiency. And a happy finding was that the drought did not result in reduced employment or seriously delayed development activity. Encouraging results have been reported from other communities as well.

Elmhurst, Illinois, a community I referred to at the beginning of this presentation, has had excellent citizen cooperation in its conservation program designed to reduce overpumping of its declining aquifer water resource. Near Washington, D.C., communities served by the Washington Suburban Sanitary Commission (WSSC) have achieved remarkable control over previously burgeoning water supply demands through conservation programs pioneered since the early 1970's. The WSSC effort stemmed initially from lack of wastewater treatment facilities,which resulted in economically costly sewer hookup moratoria. When drought hit the area in the mid-1970's, conservation programs and a conservation ethic were already well established.

A common ingredient of successful programs of conservation appears to be a user charge system with increasing cost per unit of water as water consumption increases. This is in strong contrast to the rather traditional and widespread pricing system for water; namely, a reduced unit cost as demand increases.

Over the long haul, successful programs of water conservation are likely to be seen as functions of a broader public commitment to a new conservation ethic, which will in turn involve a shift from emphasis on heavy resource use to emphasis upon resource conservation. Heavy resource use is generally characteristic of American economic and cultural history, and the necessary shift to a new way of thinking may be expected to take time and to involve some pain. Water savings will, ultimately, be seen as part of the greater, broader set of changes in cultural attitudes and behaviors just noted. With care for our environment and with determination, we can make significant transformations in our use of environmental resources without seriously altering fundamentally prized aspects of American life.

Water Conservation Through Leak Detection

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Because of the drought that was widespread throughout the United States during 1977, there have probably been more articles written and speeches given in the last year and a half about water conservation than during the previous decade. Although the main thrust of water conservation programs has been to save water, it must be kept in mind that the Federal government's interest in water conservation is also due to a desire to save energy by reducing pumping costs.

WHEN A LEAK DETECTION SURVEY IS NEEDED

Before consideration can be given to a leak detection survey as a cost-effective means of conserving water, it must first be determined whether there is enough water loss in the system to warrant a survey. Distribution system losses in a metered system are usually referred to as "unaccounted-for" water and may be defined as the difference between the water produced, or purchased, which enters the distribution system during a given period, and the amount of water delivered to the system. Quite often too much concern is shown over the fact that there is an overlap between billing periods and the period used to determine the amount of water delivered to the system. If the period used for comparison is long enough, such as a year, then the resulting unaccounted-for percentage will be indicative of the severity of system losses. In addition, a running twelve-month record can be kept of the unaccounted-for percentage by adding pumpage and billings for the current month and dropping the first month from the list. The percentage will vary somewhat with seasonal changes, but the current percentage can still be compared with the percentage for the same time the previous year. Also, any upward trend in percentage can be observed as it develops and steps can be taken to determine the causes before the losses are detected by an annual audit. In fact, an annual accounting procedure may not detect a significant increase in unaccounted-for water until almost a year and a half after the cause for the increase has developed.

Usually, in smaller water systems with average daily consumption up to ten million gallons per day (mgd), it is difficult to economically conduct a thorough survey of the system for leaks if the unaccounted-for percentage is 15 percent or less. In larger systems, the unaccounted-for percentage may be less, but it may be economically feasible to set up a leak survey program just because of the fact that losing 10 percent of a high average daily consumption represents a considerable amount of water. However, there are a number of factors, in addition to average daily consumption, that must be taken into account before a decision can be made as to whether or not a loss of 10 percent to 15 percent or less is really acceptable. One of the major factors is the amount of water sold to industry. For example, consider a water system that has an average daily consumption of 10 mgd with a 10 percent (1.0 mgd) loss and has 5 mgd of the total supplied to industry through several dozen well-maintained meters. If it is assumed that the industrial consumption is accurately metered because of an existing meter rehabilitation program, then the 1.0 mgd in loss is actually contained in the remaining 5.0 mgd in consumption. The unaccounted-for percentage then becomes 20 percent instead of 10 percent.

Another factor to be taken into consideration is the accuracy of the master meters which measure the water delivered to the distribution system. All the statistical data that is used to determine the unaccounted-for percentage is dependent on the accuracy of this group of meters. Although master meters have been found to be over-registering by as much as 20 percent on some occasions, the tendency is towards under-registration. If the master meters are under-registering, the resulting low unaccounted-for percentage could lull a community into a feeling of false security, which could result in excessive losses. If the true percentage were known it might become economically feasible to consider a comprehensive leak detection survey.

The temptation should be resisted to overestimate the amount of water used for fires, unmetered municipal services, and main breaks. Studies conducted by the American Water Works Association (AWWA) have shown that in most cases these factors only account for one or two percent of the average daily consumption.

During a drought or a program of mandatory consumer conservation, it may be necessary to inaugurate a leak detection program even if the unaccounted-for percentage is relatively low, so that the utility cannot be accused of wasting water while others are having to conserve water. Therefore, in determining when a leak survey might be beneficial, a careful analysis should be made of circumstances and of all the factors that contribute to water losses, using the unaccounted-for percentage as a guideline rather than a number with a fixed cutoff point.

TYPES OF SURVEYS

There are two types of leak detection surveys available to communities: the listening survey and the water loss survey.

The listening survey, as the name implies, is conducted by listening on valves and hydrants with sound-intensifying equipment in hopes of detecting sound that will lead to the location of underground leakage. The listening survey can be conducted by a water utility using its own personnel. Unfortunately, in smaller water systems this type of survey cannot guarantee that the problem will be solved, since the cause of the unaccounted-for water will still be undetermined if little or no leakage is located. In large systems it is difficult to set up a continuing program that is the most cost-effective at all times. In both smaller and larger systems it is impossible by sound alone to quantify the leaks so that the largest leaks can be repaired first.

The water loss survey is a combination engineering and accounting approach to an unaccounted-for problem and requires the use of a firm that specializes in solving water loss problems. Flow measurements are utilized to help determine how water is being used in the system and to determine which areas have the greatest leakage potential. The primary and recording devices of the master meters are tested for accuracy, industrial meters are tested for accuracy, pump efficiencies are checked, and leaks are quantified and pinpointed for repair. An analysis of all the data that are obtained will help determine how water is being lost in the system and will define the problem so that cost-effective measures can be taken.

Generally, if a utility has an unaccounted-for loss between 10 percent and 15 percent, a comprehensive water loss survey would result in measures reducing this loss by 10 percent to 30 percent. If the unaccounted-for loss is in the 15 percent to 25 percent range, a reduction in loss of 30 percent to 50 percent might be expected. If the loss is in the 25 percent to 50 percent range, it is probable that the reduction would be 50 percent to 60 percent.

INSTRUMENTS

There are two basic types of instruments that are used in leak detection work: the perfect instrument type such as the aquaphone and the geophone, and the more sophisticated type which contains tubes or transistors and batteries. A perfect instrument is defined as one that does not have any moving parts, will not function improperly, and will continue to perform satisfactorily with a minimum of maintenance.

The aquaphone looks something like an old-style telephone receiver and is reliable and easy to use. It is utilized primarily for checking services for leaks and for preliminary sounding on valves and hydrants. All waterworks maintenance trucks should have an aquaphone as standard equipment.

A geophone looks something like a doctor's stethoscope. It is rugged, easy to use, and is excellent for preliminary sounding and for pinpointing leaks. It has the distinct advantage of being more sensitive than the aquaphone and less sensitive than the electronic locator.

Electronic locators come in many shapes and sizes. They are more sensitive, but delicate, and require special handling when transporting and using. They are also more expensive to purchase and to repair.

There are no magic leak-locating instruments or secret procedures to be found anywhere that will be of assistance in finding leaks. Rather, the individual charged with the responsibility of locating leaks must depend on hard work, patience, common sense, and skill gained through experience.

SUMMARY

When it is considered that a leak detection survey can be implemented quickly, it becomes apparent that such a survey, if needed, is a practical and economical approach to water conservation. In many cities where it is necessary to reduce water consumption, the leak survey would be conducted in conjunction with other water conservation programs.

Distribution system losses are a luxury that no water utility can afford. Water passing through meters and not being registered is revenue lost at retail prices. Water lost through underground leakage wastes energy and valuable chemicals which are in short supply, as well as purification and wastewater plant capacity, pumpage capacity, and main capacity. In the future, proper water management, including some type of water conservation program, will have to be a fundamental part of waterworks operation in most communities.

Infiltration/Inflow

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Almost everyone is familiar with the term infiltration/inflow and how it fits into the topic of municipal wastewater flow reduction. But how is it related to water conservation?

Infiltration is, of course, water that seeps into sewer systems through mains and house services, manhole walls and the like as a result of ground water encroachment. Inflow is rainfall and surface runoff entering these systems through direct connections such as catch basins, area drains, yard drains, and roof leaders. This unwanted water is getting into the sewer system and is using capacity that would otherwise be utilized for the transportation of domestic, commercial, and industrial wastewater.

Sewer system design does take into consideration extra capacity for some unwanted waters of infiltration and inflow. However, the degree to which these waters enter sewer systems most often exceeds the amount allowed by the systems. The first sewer systems were most often combined, designed to take both the sewage and surface runoff waters into one conduit, and transport them to an outfall and eventually into some body of water. These combined systems were usually provided with overflows at various points along their routes so that the surges in the flow as a result of high-intensity rainfall runoff entering the system would be able to be relieved without causing system backup and subsequent flooding of basements and streets.

With the advent of sewage treatment and construction of sewage treatment plants, combined systems were diverted to these facilities, and subsequent system additions were of a separated nature. The separated systems directed the wastewater to the treatment facilities via sanitary sewers, and the stormwater runoff was directed to the nearest water course via storm sewers. Thus, in the separated sanitary systems, there was very little extra capacity for extraneous waters of infiltration and inflow. As a result, when waters of infiltration and inflow entered the separated sanitary systems, and used capacity that otherwise had been provided for the transportation of normal wastewater flow, they caused the systems to be stressed. Many times systems became overloaded.

System overloading causes basement flooding, overtopping of manholes, and bypassing from sanitary to storm sewers through "bootleg" connections, perhaps, which direct stormwater runoff toward the nearest receiving body of water. Such an occurrence, of course, results in the pollution of these water courses.

The tie, then, between a discussion on infiltration/inflow and the conservation of water becomes clear. When domestic water supplies are drawn from these same water courses, the extensive treatment necessary to make these waters potable becomes a difficult or even impossible task. This paper will discuss past, present, and future perspectives on the subject of infiltration and inflow.

Let's take a look at the recent history of sewer systems. Books have been written about the origin of sewer systems, going back centuries to the Romans. However, in this country, we are concerned mostly with the last 100 years. There are systems older than that, but in most major cities in this country, the oldest systems go back about a century. There is not a great deal of sewer footage that old, but in many cases some of the more critical footage in a community lies in its older systems. Allow me to clarify that. Cities, of course, build out from a core and because of that fact, the older systems are in that core, which usually is the more highly developed area. The extent of development makes the systems less accessible for maintenance than, perhaps, some of the newer systems in outlying parts of cities. As a result of that inaccessibility, systems have been neglected in many cases and have deteriorated. Let's face it, sewer system maintenance is not usually at the top of the list of priorities for a city's allocation of funds.

Now let's look at the design practices, the construction practices, and the materials of construction as they have developed for sewer systems over the years. First of all, it is anybody's guess as to what procedures were used in designing the 100 year-old systems, 50 year-old systems, or for that matter, present-day systems. Have good practices been used? Let's hope that they were. Secondly, the systems were designed by any number of different people, both engineers and non-engineers. We are dealing with a human factor that acknowledges that perhaps good designs were used, but on the other hand, whatever was convenient to expedite design and construction may have been utilized.

Now, how about construction practices? Those of you who are familiar with sewer construction know that unless there is good inspection on competitively bid projects, there is the potential for the projects to be subject to less-than-ideal construction practices, especially on a job that is difficult or one where a contractor might be behind schedule. These situations have existed over the years. Also, many different additions to a system may have been done by many different people. Looking at that "patchwork quilt" of circumstances leads one to wonder what must be underground. Those of us in the business of investigating old systems know what is underground. Some of the things we find are atrocious, not because of deterioration due to the age of the systems, but because of practices undertaken at the time of construction and from all the factors of design, materials, and construction.

As for materials of construction, early sewer systems were built of concrete and vitrified clay pipe, both of which are still used. However, improvements have been realized; materials such as ABS and PVC are now being used. But perhaps the biggest improvement has been in the methods of joining pipe. The gasket materials, going back to oakum, mortar, jute, and bitumastic material, are now being replaced by slip-on gaskets and chemical weld joints.

Earlier I mentioned the different types of systems. The first systems installed were combined, handling domestic, commercial, and industrial waste along with the stormwater runoff. Again, there have been different philosophies with regard to how these pipes should be installed, expecially with reference to the use of, or the lack of, gasket material. In some cases, pipes were installed without gaskets to allow them to act as "french drains" to keep the water table down. At first, it may be argued that since the pipes are supposed to be carrying runoff, they may as well take seepage infiltration and keep the ground water table down. What happens, however, is the phenomenon of exfiltration, or leakage of wastewater from the sewer pipes into the surrounding soil. Many of the systems have been exfiltrating for a number of years, leading one to speculate on the condition of the ground water in the vicinity of these systems.

Because sewage treatment plants now accept all or most of the flow from these combined systems, all of the extraneous water entering becomes something that requires treatment. There is a large problem in removing all of the direct inflow connections to combined sewers. When they have been in the ground for up to 100 years the number of connections made to these systems is phenomenal and, for the most part, unknown. Also, where the combined systems have been separated and what was once a combined sewer is now the sanitary sewer, the lack of jointing materials (in addition to the other problems with the old combined system) becomes a matter of concern.

With sewage treatment plants on the ends of all these combined systems, the subsequent sewer construction was of the nature of separated systems. Once again, factors of design, materials, and construction are involved.

A myriad of situations exist in the separated sewer systems. One clear water source which poses a removal problem is footing drain tile connected to separated sanitary systems. These tiles are placed around a foundation of a home to keep the water table down and to prevent the basement floor from buckling and leaking. This water is often directed to the house service, directly or "bootlegged' through sump pumps. The Federal Housing Administration required the installation of footing drain tile for a number of years, and the recommended place to connect them was to the house service. Now, new construction practice provides for the footing tile to be connected to sumps and to be pumped to some place other than the sanitary sewer system. However, hundreds of thousands of pre-existing homes have footing tile discharging to the sanitary sewer system.

Another clear water source occurs where separated storm sewer systems that were constructed to handle surface runoff are in proximity to the sanitary system. The sanitary system is usually deeper in the ground than the storm system, which results in the storm sewer mains crossing over the sanitary sewer mains and house services. As I mentioned before construction of storm sewers quite often is done without the use of jointing materials, and exfiltration occurs during periods of rainfall when these lines are transporting surface runoff. Exfiltration water will flow from the storm sewer mains and into the sanitary sewer mains and house services at any point where the sanitary systems are capable of taking on water. Experience has shown that this inflow problem is one of the most serious occurring in sanitary sewer systems.

Sewage treatment plants and the subsequent receiving bodies of water are being affected as a result of the sewer systems' susceptibility to taking on extraneous clear water of infiltration and inflow. As more of this water enters the systems, wastewater treatment plant capacities will have to be expanded, increasing capital costs as well as operation and maintenance costs. Another factor to consider is the very large surges of flow experienced during periods of rainfall and snowmelt runoff into these systems as a result of inflow. This increases the risk of health hazards caused by basement backup, manhole overtopping, overflowing and bypassing to storm sewers and subsequently, discharge to receiving bodies of water. The problem has been recognized for years; however, until the advent of Public Law 92-500, the Federal Water Pollution Control Act Amendments of 1972, there was little importance placed on removing the clear waters of infiltration and inflow from the sewer systems. Prior to P.L. 92-500, no recognition or addressing of the infiltration/inflow problem was necessary, except in a very peripheral manner, to obtain federal monies for the construction of sewage treatment plants. Under P.L. 92-500, the recognition of infiltration/inflow problems was addressed by requiring sewer system studies to identify the effects of infiltration/inflow.

An infiltration/inflow analysis is required to identify the problem and to make a decision as to whether there is a possibly excessive infiltration/inflow problem in a sewer system, or if it is nonexcessive. If the problem is possibly excessive, then a further in-depth study, known as a sewer system evaluation survey, is required. It is interesting to look at how these studies, or the guildelines for these studies, were developed. The history of how these programs evolved merits a brief discussion.

Going back to sewer system design prior to the early 1960's, we see a provision in design for an infiltration allowance. Only the word infiltration, not inflow, was used at this point. Infiltration included any extraneous water, whether it be seepage ground water infiltration or rain water.

During the late 1950's and early 1960's, the technique of televising sewer systems was developed. The reason was that municipalities had never been able to really look at their systems as they would like to. The only inspection technique available up to that time was visual lamping; most often, 50 feet was about the distance one could see effectively into a small diameter sewer line from a manhole, and the average distance between manholes is 250 to 300 feet. Street cave-ins and things of this nature are a common occurrence and are often the result of structural failure of the sewer system, causing the backfill and overburden to pull down into the system. This, in turn, causes cavitation beneath the street surface, with a resulting collapse of the pavement. The municipalities recognized sewer televising as a tool to investigate systems for structural integrity before placing new pavements over them. Along the way, however, while cameras were in the lines, many other situations were noted, including infiltration. And, from time to time, when televising was done during heavy rainfalls, the marked increase in flow was noted. A line that was flowing about a tenth of its capacity suddenly filled with water, inundating the television camera. As a result of situations like these, questions of "why" were raised which spurred the development of new technology. Hence, rainfall simulation was born.

Presently, rainfall simulation takes several forms. A major form is dye-water flooding of adjacent and crossing storm sewers. One of the largest contributors of clear water of inflow are the storm sewers that lie adjacent to the sanitary sewer systems. Over the years, "bootleg" connections--cross-connections--between storm and sanitary sewers have been made to relieve the sanitary sewer systems that become overloaded, thus preventing basement backup and manhole overtopping. These kinds of cross-connections are, of course, very large sources of inflow when the storm sewer system takes on surface runoff water. The water then passes from the storm sewer to the sanitary sewer and defeats the purpose of the cross-connection, which is to relieve the sanitary sewer system. However, there is a more insidious form of storm water inflow which is a result of exfiltration from the storm sewer system via the joints, with this leakage permeating the soil in the vicinity and eventually migrating to the sanitary sewer mains and house services, which are ususally at a lower elevation.

It is surprising how long it has taken engineers to realize that this is a major source of inflow. I can cite my own example when, working as a city engineer in a municipality in Wisconsin, I first heard of storm sewer flooding. I did not believe it was necessary. The company who performed televising services for the municipality at that time (in the mid-1960's) always flooded the adjacent storm sewers prior to televising. It took actual onsite evidence for me to realize that this was a large source of inflow. I had thought, like so many other engineers, that exfiltration from the storm sewer system was not a problem, much less the infiltration of that water into the sanitary sewers. This method is now an accepted technique for determining sources of inflow: dye is inserted into the water put into the storm sewer system and a subsequent check is done to see if the dye shows up in the adjacent sanitary sewer. With this evidence, then, those sections of the sanitary sewer where dye shows up are recommended for televising. Then, at the time of televising, the storm sewers are reflooded, this time without the dye, to allow the camera to spot exactly where the waters are inflowing into the sanitary sewer system.

So, the problems in the sewer system as they concern infiltration and inflow were recognized for what they were, almost accidentally, with the advent of sewer system televising for structural purposes. The various techniques for sewer investigation started to develop at that point, and one of the first phases was called physical survey. This is a process where the manholes are descended and the lines illuminated to get an idea of the amount of cleaning that is necessary in the sewers prior to televising. This technique was developed and refined so that it also helped to identify areas of infiltration and sources of inflow. The television camera could now be used in a more intelligent and restrictive way, rather than in haphazardly looking for the clear water sources. As these techniques evolved, studies were performed to identify sources of infiltration and inflow and the flow readings at the sewage treatment plants during various dry and wet weather periods were compared, along with water consumption to quantify, in total, the infiltration/inflow problem. With this quantification, then, a target was established when looking for the various clear water sources. One knew how much clear water was getting to the treatment plant but did not know the origin of this water. So, the investigative phases were the tool by which the sources, in total, would equal what was determined as the overall problem. As more studies were undertaken, it was realized how much of a problem clear water in sewer systems really was. Also, the amount of this water getting to the treatment plant most often was only part of the problem because of overflows and bypasses in the system, causing a mixture of clear water and sewage to exit at these points.

When P.L. 92-500 was in its formative stages, the Federal government recognized that it would not be efficient to construct treatment plants to handle the large wet weather flows that were occurring. Rather, a program was needed to identify and prevent at least some of the extraneous water from getting into sewer systems.

As part of P.L. 92-500, then, the government initiated a requirement that each sewer system tributary to a Federally-funded project such as a wastewater treatment plant or interceptor sewer undergo an infiltration/inflow analysis to determine if the infiltration/inflow from that system was possibly excessive or nonexcessive. The infiltration/inflow analysis was intended as more of a "desk-top" study that investigates flows exiting the system and attempts to determine whether it would be cheaper to transport and treat them, or whether a reduction of the clear water would be the most economical alternative. If the latter is true, then a sewer system evaluation survey must be performed.

As with any new program, there have been problems. The Federal government has been criticized for including the sewer system investigation requirement in the law. Some people maintain that while the intent is laudable, the application is impractical. Others disagree with the intent of the law, feeling that facilites can be constructed in all cases to handle these flows. Whatever the various opinions, one must look at how the program has progressed since 1972.

At the outset of the program, no one really knew what was necessary to meet the infiltration/inflow analysis stipulation. As a result, there were a lot of "cut-and-try" procedures. Guidelines were written at the time; however, they were usually not specific enough to enable people to perform the task required to the satisfaction of the people formulating the guidelines. Also, individual interpretation played a large role in completing infiltration/inflow analysis.

The people who first started the program in the Federal government were as much in the dark as the people trying to perform the work. Along the way, from the consultant point of view. it has been difficult to deal with the changing government personnel. Also, the practicality of the specific requirements for an infiltration/inflow analysis, or for that matter, sewer system evaluation survey, is always in question. The more experience that one obtains in these areas, the more one learns that adjustments to requirements are necessary. This, then, results in the need for change. The Federal government has come out with various Program Requirements Memoranda that update, revise and change procedures. Thes Memoranda are also subject to individual interpretation. Hence, a wide variety of approaches have developed to solving the problems of infiltration/inflow.

But, let's look at the subject from a different point of view. Suppose there was no requirement for addressing the clear water of infiltration/inflow in the sewer system prior to constructing facilities to treat the flows. It is not too difficult to imagine what would have happened. Tremendous overdesign to accommodate the clear water would have taken place. The awareness created by the requirement for infiltration/inflow has had a very stimulating effect on the population. Municipal people are now more aware of some of the problems which occur in their sewer systems. The general public is more aware of these problems through their participation in government programs. Environmentalists and others also see that addressing of these problems can benefit the things of nature. Unless a serious problem like infiltration/inflow is brought to our attention by such laws and made one of our concerns, we tend to ignore it and put it aside.

Well, where are we now with the concerns of infiltration/inflow? Most systems have addressed the problem through infiltration/inflow analysis. We are in the midst of performing sewer system evaluation surveys on those systems deemed possibly excessive by the analyses. Some surveys have been completed, others are in various stages of completion. Consequently, there have not been very many projects that have reached step three, or the rehabilitation phase, as yet. One thing has become abundantly clear, though: infiltration, per se, is not cost-effective to eliminate from a sewer system in most cases. Techniques for infiltration elimination are usually rather expensive for the amount of infiltration eliminated. Some projects have proceeded into the rehabilitation phase where extensive work has been done to eliminate infiltration and, in fact, the problem has not been eliminated at all. It is only moved around.

Inflow seems to be the much larger concern and there are several reasons for that. First of all, it has a very large immediate impact on a sewer system. Inflow-related flows are generally the most problematical, since they cause basement backups, manhole overtopping, and sewer overflowing and bypassing. Inflow sources are relatively inexpensive to eliminate for the amount of water that is removed from the system.

Another situation that has been a problem is combined sewer systems. Until just recently, little has been done with combined sewers. Most of the bigger cities have not begun the sewer system evaluation survey phase, and these are generally the cities that have at least some combined sewers in their systems. The Federal government has issued Program Requirements Memoranda addressing the problem of combined sewers. It seems that sewer separation is the recommended procedure; however, most often, it is not the most cost-effective alternative, and other solutions to the problem become apparent, such as flow equalization and storage.

Since all bypassing must cease, and since there are large quantities of surface water that must be handled, the practicality of some of the recommended methods of rehabilitation in sewer systems has proved to be inadequate to eliminate bypassing. But, these problems must be addressed. We can't ignore the problem or take a negative attitude because the intent of the program is certainly right, and the results will depend upon how well we apply ourselves to alleviating this problem.

What lies ahead for us with regard to elimination of bypassing, the tightening up of systems? What must be done in the future?

The first thing that must be done, and is being done, is that systems installed henceforth will be constructed under rigid infiltration/inflow specifications and inspection procedures. This is a difficult thing to achieve, but we must strive for that goal. The disallowance of clear water connections to sanitary systems must be enforced and some of the practices prevalent in the past with regard to connections must be stopped. Once a sewer system has been investigated and the necessary rehabilitation measures taken, it is incumbent upon the owner to be vigilant in checking to see that minimal flows are maintained. A continual program of flow monitoring, in some form, must be initiated along with improved maintenance procedures for keeping the system tight and at full capacity. Eventually, older systems will be corrected, at least to some degree, and later, of course, many of the older systems will be replaced.

As bypassing is eliminated and all of the flows are handled in the system and transported to the treatment facility, and as the facilities themselves are upgraded to accomplish a higher degree of wastewater treatment, the receiving waters in this country will become less polluted and easier to treat for human consumption.

Perhaps the original balance of nature will never be restored, but with the available technology, we will certainly to able to handle our human problems as they are concerned with the water supplies of this country.

Selection of Water Conservation Devices for Installation in New or Existing Dwellings

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INTRODUCTION

One of the most difficult decisions for utility managers interested in water conservation has been the selection of the best fixtures, fittings, and devices to recommend to their customers. In the early days of such programs the choice was not so difficult because there were very few water conservation fixtures and devices available. However, the choice is considerably more difficult today because there are many more water-saving products on the market. Many of these products look and function similarly, making the choice between them even more difficult. Second, many water conservation devices have not been rigorously tested by standard methods to allow the decisionmaker the opportunity for a clear judgment as to their relative merits. For example, the U.S. Department of Housing and Urban Development has only recently retained a consultant to develop a suitable standard for testing water-saving toilets.

These tests for product reliability are still not enough. The decisionmaker also wants to know what he can expect in the way of savings in water, energy, and wasteflows both from individuals and in the aggregate for his community. This information is only now beginning to become available, and,because of differences in measurement methods, individual water use, device distribution methods, and a whole host of other variables, this data must be interpreted carefully.

Until now, the utility manager has been compelled to test and demonstrate water conservation devices in selected homes within the community prior to recommending their widespread use. Such efforts are often limited by inadequate monitoring and nonstandard evaluations. These independent tests are duplicative and delay conservation program implementation, but they have

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been required because of a lack of good performance data for many water conservation devices and fixtures.

Although by no means complete, there is now some information available on the performance of water conservation devices. This information should help the utility manager choose the water conservation devices and fittings that are most suitable for his particular situation. This discussion will be confined to devices used in the home. The growing family of devices available to manage outdoor residential water use is not within the scope of this paper.

Toilet Devices

In the residential setting, the largest user of water inside the home is the flush toilet. Data on the amount of water used by flush toilets vary, but a generally accepted average is five gal/flush. Because of its relatively high water use, the toilet has received a lot of attention from those interested in water conservation. A varied assortment of devices has been developed to modify the toilet to use less water,and new toilets are being marketed that use less water. Most residential water conservation programs have encouraged the use of devices to modify existing toilets and mandated the use of water-saving toilets (3.5 gal/flush) in new or replacement construction.

The choice of devices for use in existing toilet installations has been especially difficult for utility managers. Available devices include dams, partitions or inserts to wall off a portion of the toilet tank, displacement devices such as plastic bottles or bags to displace water in the toilet tank, and an assortment of devices to modify the flush mechanism for a two-cycle flush mode. Most programs involving mass distribution of water conservation devices have relied on either dams or displacement devices. Mass distribution of two-cycle devices has not occurred.

The relative merits of one type of toilet modification device versus another have only recently received attention. For the purposes of this paper an attempt has been made to give additional insight into questions concerning toilet device selection. The three major types of devices--damming, displacement, and flush mechanism modification-- are compared on the basis of water use reduction efficiency, cost, installation problems, and performance under conditions of actual use.

Water Reduction Efficiency

Table 1 summarizes the water use reduction efficiency of 10 toilet dams. The data presented is taken from tests conducted by the California Department of Water Resources.

Averages from Table 1 show a savings for the plastic dams tested of 1.56 gallons or 29.8 percent of total water use/flush. The averages for two one-quart displacement bottles reported in this same study are 0.65 gallon or 12 percent of toilet water use/flush.

TABLE 1. WATER REDUCTION EFFICIENCIES OF TEN TOILET DAMS

Device	Average volume of water saved per flush* (gal.)	Average flush water saved (%)
1	1.42	27
2	1.43	27
3	1.34	26
4	1.34	26
5	1.59	30
6	1.73	33
7	1.73	33
8	1.53	29
9	1.61	31
10	1.89	36

* Average of three flushes in each of three common toilets by procedure outlined in ANSI A112.19.2-1973. All test toilets with flapper valve.

The California Department of Water Resources study also evaluated the flushing efficiencies of various flush mechanism devices. This evaluation is summarized in Table 2.

Those flush-mechanism devices not accomodating a two-cycle flush mode had an average savings of 2.10 gallons or 40 percent of average toilet flush water use. Those accomodating a two-cycle flush mode showed an average savings of 2.60 gallons or 51 percent on the liquid cycle and 1.26 gallons or 24 percent on the solid cycle.

Tests recently conducted at the Pennsylvania State University compared the water reduction efficiency of plastic bottle displacement devices and toilet dams. The major difference between these tests and the California tests is that three bottles were used having a total capacity of approximately 1.25 gallons instead of the two one-quart bottles utilized in the California test. The result of these comparisons is given in Table 3.

The data from the California study of water reduction efficiency are compared in Table 4.

The data presented in Tables 3 and 4 show that maximum water reduction efficiencies occur with two-cycle flush mechanism devices. Other flush mechanism modifications were a close second. Toilet dams were rated third by the tests, followed very closely by the bottle configuration used in the Penn State study.

It should be pointed out that these comparisons are simply for water reduction efficiency only. No attempt was made to simulate actual conditions by introducing solid material into the toilet bowl; consequently, these results may not be valid under conditions of actual use where solids clearance from the toilet bowl and other potential problems may be a factor.

Similar tests conducted by Consumer Reports' staff lead to the conclusion that plastic bottles or a homemade flush mechanism device were about as effective as any of the toilet devices that they tested.

INSTALLATION PROBLEMS

The relative difficulty of installing toilet insert devices is a variable and highly subjective factor. Mechanical operations of this type may be difficult for some and not for others, depending upon aptitude and interest. In addition, the installation instructions may not be well written,or it may not be clear which toilets accept a particular device and which do not. The California Department of Water Resources used a subjective numerical scale in an attempt to compare the relative installation difficulties of various toilet devices. In summary, the California results, using several variables related to installation problems, rank plastic bottles, toilet dams, flush mechanism modifications, and dual-cycle flush mechanism modifications respectively in order of increasing difficulty of installation. However, there are specific devices in each of these categories that do not fit this overall ranking. As a general rule, plastic bottles are the easiest to install of all types of toilet devices.

TABLE 2. WATER REDUCTION EFFICIENCIES OF FLUSHING MECHANISM MODIFYING DEVICES

Device	Cycle	Average volume of water saved per flush* (gal.)	Average flush water saved (%)
1		2.14	41
2	liquid	2.95	57
	solid	2.40	46
3		1.90	36
4		1.96	37
5	liquid	2.26	44
	solid	1.37	26
6	liquid	2.58	53
	solid	0.00	--
7		2.86	54
8		2.04	39
9		2.17	42
10		1.88	35
11		1.82	35

* Average of three flushes in each of three common toilets by procedure outlined in ANSI A112.19.2-1973. All test toilets with flapper valve.

TABLE 3. WATER REDUCTION EFFICIENCY OF TOILET DAMS AND 1.25-GALLON PLASTIC BOTTLES

Device	Average volume of water saved per flush* (gal.)	Average flush water saved (%)
Test #1		
Dams	1.11	33.5
Bottles	0.95	28.9
Test #2		
Dams	1.47	31.7
Bottles	1.24	26.7

* Tests were conducted on toilets in actual use under varying conditions of water pressure. Values reported are valid for this comparison only. Based on an average of three flushes in three different toilets at three different locations, for three different toilet dams.

TABLE 4. WATER REDUCTION EFFICIENCIES OF TOILET WATER CONSERVATION DEVICES (CALIFORNIA DEPARTMENT OF WATER RESOURCES PROGRAM)

Device	Average volume of water saved per flush (gal.)	Average flush water saved (%)	Range of flush water saved (%)
Dams	1.56	30	26-36
Bottles (0.5 gallons)	0.65	12	0
Plastic bags	0.91	17	13-26
Flush mechanism with two cycle*	2.27	43	37-54
Flush mechanism without two cycle	2.10	40	35-54

* Weighted average based on three liquid flushes for every solids flush.

COSTS

Cost comparisons between the types of toilet devices available show that plastic bottles are by far the cheapest, followed in order by toilet dams and flush mechanism modification devices. Prices for all devices vary from less than a dollar up to $10.00, with the majority selling for less than $5.00. Although as a group, flush mechanism devices cost more, many of these devices are less expensive than toilet dams. Plastic bottles are available at a fraction of the cost of other devices.

PERFORMANCE

Very little information is available on the performance of toilet dams and flush mechanism devices. In the California study an attempt was made to determine the importance of various attributes in relation to the toilet devices under consideration. Those attributes describing the performance of the device over the long term were judged to be more important than others related to attributes such as cost, amount of water saved, and ease of installation. Intuitively, it would seem clear that the American public would be unwilling to accept any toilet modification that impaired the normally reliable day-to-day functioning of the toilet. Consequently, given the low cost and ease of installation of most toilet devices, the durability and maintenance requirement of any device is probably a paramount criterion in judging the overall suitability of a particular device for a retrofit program.

As has already been pointed out, laboratory tests of water reduction efficiency are in no way indicative of how well the device will hold up under continued use or how well the toilet will function with the device in place. There is still very little information available on the long term performance of flush mechanism devices; however, some experience has been gained from the use of toilet dams in mass retrofit programs. Sharpe and Fletcher (1977) reported on the first such program in the United States conducted in 1972 by the Washington Suburban Sanitary Commisssion (WSSC). This study showed that four years after installation 42,50, and 92 percent of the three devices evaluated were no longer in service. The devices used in this study were not of the single-panel type, but the experiences of several water conservation program managers indicate that similar problems also exist with single-panel devices.

It would appear from the information presented that plastic bottles are the most suitable device from mass retrofit water conservation programs. Plastic bottles are less expensive, more durable, and easier to install than toilet dams. They can be adjusted by either removing bottles or reducing their size. Data reported by Sharpe and Fletcher showed that 100 percent of those receiving bottles in the WSSC program still had them installed four years later, although the size of the sample surveyed is quite small. Flush mechanism devices have not been evaluated sufficiently under conditions of actual use to allow a judgment as to their effectiveness as a water conservation tool. However, the reported savings from bench scale tests of flush mechanism devices with a dual flush mode appear to warrant further investigation into their use for mass retrofit programs.

WATER-SAVING TOILETS

Several States and many local jurisdictions have passed laws and code changes requiring 3.5 gallons/flush water-saving toilets. Requirements for water-saving toilets were first adopted by the Washington Suburban Sanitary Commission in 1973. Sharpe and Fletcher evaluated this program and concluded that there were no substantial problems with this approach to water conservation. Minor problems were reported with adequate flushing of solid materials from the toilet bowls in some installations; however, these problems reportedly have been or are being corrected by the plumbing fixture industry. Requirements for water-saving toilets were well accepted by both the installers and users of plumbing fixtures.

In California, where water-saving toilets have been required in new construction since January 1, 1978, early indications are that the program is progressing well and producing the desired results.

However, recent tests by Consumer Reports have indicated that most water-saving toilets are not as good as conventional models. The Consumer Reports' test procedures are not well defined nor is their language precise in describing test results. Consumer Reports did recommend two toilets as being as good as conventional models and superior to the others that they tested.

The findings of Consumer Reports bear out those of Sharpe and Grear in that both indicated differences in the performance of water-saving models currently on the market. Problems with water-saving toilets in actual use would seem to be less than bench scale tests indicate. Surveys conducted in the Washington Suburban Sanitary Commission service area by Sharpe and Fletcher indicate that 79 percent of the installers and 82 percent of the users favored code requirements for water-saving toilets, with only eight percent of the latter indicating they did not favor such requirements.

Requirements for water-saving toilets in new and replacement construction should be considered as an integral part of every water conservation program.

SHOWER DEVICES

Reportedly, the second largest use of water in the home is for bathing and showering. Most authors report bathing and showering to account for approximately 30 percent of household water use.

Water conservation programs involving the retrofit of shower flow controls and restrictors in existing dwellings have been conducted at numerous locations around the country. In almost all cases the sponsoring utility has purchased the devices and distributed them at no cost to its customers. Because of the large aggregate cost of the devices, most utilities have selected shower flow restrictors of low unit cost for mass distribution. One notable exception is Hamilton Township, New Jersey. Most of the restrictors used have been designed to limit flows to a maximum of 3.0 gallons/minute (gpm) at a water pressure of approximately 50 pounds/square inch (psi).

Limited physical testing of shower flow devices has been undertaken by several agencies with extensive recent tests by the California Department of Water Resources. Additional test results involving subjective evaluations by a selected group of shower users have also appeared in Consumer Reports. Additional work as yet unpublished is under way at the Pennsylvania State University.

Most of these testing programs have placed heavy emphasis on the flow rate characteristics of the shower device at either a single water pressure or at several water pressures simulating the range of service pressures experienced in water supply systems. Additional criteria such as ease of cleaning, type of construction, appearance of the device, and cost have also been applied to the shower device selection process. In some cases a subjective evaluation of the quality of the shower has also been made by soliciting the opinions of users.

Flow rate comparisons are of limited value in judging the suitability of shower devices because they bear little relation to the quality of shower received by users. In general, the device that most closely approximates the selected flow rate (usually three gpm) for the water pressures used in the test is judged best. However, if the shower is as satisfactory at 1.5 gpm and 30 psi as it is at 2.5 gpm and 80 psi, the difference in flow rate matters little to the user. In fact, such a difference may be desirable in that it does allow for some variation in water flow to accomodate the preferences of different users. Such variation may be obtained by the user by opening cold and hot water valves wider to allow for greater water flow.

Another criterion that has been used to judge shower devices is that of spray adjustment. Some evaluators have felt that the showerhead should be adjustable from needle to gentle spray with the device in place and that both of these sprays should be satisfactory. Whether or not an adjustable spray is really important to the average user is a matter of conjecture.

Cost is a criterion used to judge shower devices that has often been misapplied. Certainly, devices that meet all other established criteria should be differentiated on the basis of cost, but all too often cost is weighted too heavily in comparison with other criteria. The result has been selection of cheaper devices that involve greater risk of poor user acceptance or devices that are not effective conservers of water. Device costs are only one factor in the cost decision. Distribution costs, costs of discarded or unused devices, and the cost savings resulting from the use of the device must also be considered. In the long run it may be more economical to select a device with a much higher initial cost.

Determining the maximum flow rate of the shower devices to be selected is also an area of potential difficulty. National codes have suggested maximums of 3.0 gpm. The American National Standards Institute (ANSI) standard is 2.75 ± .25 gpm, which is essentially a 3.0 gpm standard. Most of the really inexpensive devices are engineered to limit flows to three gpm at a pressure of approximately 50 psi. With most cheap restrictors maximum flow rates below three gpm would cause a higher risk of producing an unacceptable shower, especially at lower water pressures. Unfortunately, maximum savings of water cannot be achieved at flow rates around three gpm, and savings resulting from the use of such devices may be disappointingly modest. Devices are available that give an acceptable shower at two gpm with a much greater actual savings of water; consequently, the two gpm device should be given much stronger consideration than it has in the past, irrespective of the higher costs of some of these devices.

The most important criteria for selecting a shower device are user acceptability, amount of water saved, durability, compatibility with existing installation, and, lastly, cost. The two gpm all-metal showerhead with the necessary ball joint adapters meets these criteria. Follow-up surveys of user acceptance of mass distributed shower devices show a user installation rate of 40 percent for a less costly plastic showerhead with built-in restrictor and 65 percent for a two gpm showerhead.

Code requirements for water-saving showerheads in new construction should specify a maximum flow rate of 2.75 gpm as per ANSI A112.18.1- 1978 until more information becomes available on user acceptance of two gpm devices.

AUTOMATIC WASHING MACHINES

Water for laundering is usually the third leading user of water in the home. Up to 40 percent of this water can be saved by selecting a front-loading automatic washer that allows for wash cycle adjustments based on load size and other factors. In new homes or when replacing an old automatic washer, a water-saving model should be selected.

FAUCET DEVICES

Water used at utility, lavatory, and kitchen sinks does not account for a high percentage of total household use, but modifications to faucets at these locations is still warranted. Most mass retrofit programs have ignored this area because of the relatively low potential savings. Flow rates from faucets other than the tub filler should be limited to a maximum of one gpm. Most recent code revisions stipulate maximums of 2.5 gpm. If shutoff valves are provided for the hot and cold water service lines to the fixture, they may be partially closed to allow a flow of one gpm from the hot and cold water faucets. Adjustment can be made by timing the filling rate of a vessel of known volume. If a single, center-set faucet is in use, the cold and hot water lines should be set to deliver a maximum flow of 0.5 gpm. However, if the kitchen sink is used frequently for washing dishes, such a low maximum flow rate may be undersirable.

Various inexpensive and easily installed faucet aerator-flow control devices are available to fit threaded spouts. Care should be exercised in the purchase of such devices because faucet thread sizes and diameters vary considerably. These devices are easily installed.

LEAK DETECTION TABLETS

Leak detection tablets have often been included in mass water-saving device distribution programs. The tablets are used to determine whether or not toilets are leaking water from the tank into the bowl at a rate not noticeable to the homeowner. Limited available data indicate that 14 percent of toilets in service may be leaking. The California Department of Water Resources tested a number of these tablets as a part of their water conservation program. The formulations of the tablets were reviewed by a toxicologist to ascertain potential hazards to children, and all but one of those reviewed were found to be safe. The tablets vary in cost, and some difference in their rate of dissolution was noted. The reader is referred to Appendix H of the California Department of Water Resources Bulletin 191 for the test results.

PRESSURE-REDUCING VALVES AND SPRAY TAPS

Pressure-reducing valves have been required in new construction by the Washington Suburban Sanitary Commission since 1973. These devices are placed in the main supply line to houses where water pressure exceeds 60 psi. Their function is to reduce service pressures to the 50 to 60 psi range. Little is known about the savings attributable to such devices, but they are recommended in new construction to reduce water use, pipe hammer, and frequency of fixture maintenance.

Spray taps were first researched in England in the 1950's. Their use has not been widespread in this country despite the significant water and energy savings reported by this earlier work. Some commercially available spray taps limit flows to 0.75 gpm and have built-in mixing valves. These units are only recommended in new or replacement construction. They are more costly than conventional hardware, but they enable cost reductions in other plumbing system components, and reported savings over the long term easily pay back the higher initial cost. The use of spray taps should be encouraged in all institutional type lavatory installations. The reader is referred to Walker Crosweller and Co., Ltd., for more information on spray taps.

RECOMMENDATIONS

Retrofit Programs

For programs involving the mass distribution of water conservation devices the following are recommended:

- Weighted plastic bottles having a total capacity of 1.25 ± 0.25 gallons. In some toilets the maximum bottle capacity may be limited to 0.5 gallon. The suggested bottle configuration is two 0.25-gallon bottles and one 1.0-gallon bottle, reduced to 0.75 gallon capacity for each toilet in the dwelling.

- Showerhead producing a flow rate of approximately 2.0 gpm at or near 50 psi service pressure with the required ball joint adaptors, if necessary

- Dye tablets of nontoxic formulation and easily dissolved

- Information explaining the installation of all devices and other water-saving suggestions for the home.

Newfit Programs

For programs involving the regulation of new or replacement construction, the following is recommended:

- An ordinance or code change requiring water-saving toilets (3.5 gallons/ flush) at a specified pressure in all new or replacement construction where tank-type toilets are to be used

- Water-saving showerheads designed to operate with a maximum flow rate of 2.75 ± .25 gpm (ANSI A112.18.1-1978).

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Decreasing the Household Water Demand by Design

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During the past decade I have observed both government and industry "tampering" with probably the most "sacred cow" in America...our automobile. This "cow" has been put on a diet, lost 1,500 plus pounds in the process, had its design streamlined by new materials and innovative ideas, and is starting to achieve respectful mileage with the demise of the huge 400 cubic-inch engine. The peculiar thing is that there has been little, if any effect, on the consumer's daily life. Most of us have adjusted to 55 mph speed limits, the smell of catalytic converters, and have accepted these changes as a fact of life. Why? The answer is simple...the energy shortage facing us now and in the future.

We all face a similar shortage of water, which in some cities is creeping very close to the supply capacity. It's time again to conserve, because we don't have a choice.

It's also time to tamper with the antiquated water distribution systems that predominate in our homes. Instead of targeting this discussion around the three most common water-using appliances--the dishwasher, clothes washer, and garbage disposer--I would like to concentrate on the water wasters. None of the above three fits into that category.

The common faucet is probably the most used water waster in the home. When it's used, it's typically either off or full on. Full on can mean up to five gallons per minute (gpm) of water that is used to brush teeth, wash hands, or shave. If it's warm water the user is after, the water is run until the cold water clears the pipes and hot water finally arrives at the faucet from a distant hot water heater. Heated water wasted in this manner has been estimated at eight gallons per capita per day. That figures out to almost two billion gallons per day, plus the $10 million to heat this wasted water. Our bad habits also cause us to leave the faucet on while shaving, brushing our teeth, or doing the dishes.

Let me suggest three possible solutions to this problem:

A. locate the water heater in close proximity to the faucet

B. restrict the flow to a reasonable amount

C. provide better and more convenient faucet controls that are forgiving of our bad habits.

SOLUTION A

Locating the water heater next to the faucet is what I call "point-of-use" water heating. A small tank between ½ and 1½ gallons is more than sufficient for most vanities and provides instant hot water without the waste inherent in long distribution lines. "Point-of-use" water heating, although relatively new to this country, has long been used in Europe and other less energy- and water-fortunate countries.

SOLUTION B

Restricting the water flow to a reasonable amount is fortunately being accomplished now with the use of flow restrictors that limit faucet flow to a 2.75 gpm maximum. Although that is an admirable step in the right direction, hardware exists today that can provide excellent spray patterns and flows of as little as ½ gpm.

SOLUTION C

Providing better and more convenient faucet controls is not new, but these controls are not widely used beyond certain industrial/commercial applications. A combination of a thermostatic valve, to automatically mix the hot and cold water, and a foot- or proximity-operated faucet would be a big step towards reducing wasted water by allowing the user a convenient method to turn the faucet on or off without interrupting what he is doing with his hands.

The largest water wasters are the bathtub and shower. A tub requires an average of 36 gallons per use while a shower averages about 20 gallons per use. I believe the day is fast approaching when the bathtub will be a luxury few of us will want, simply because of water and energy costs. The shower, however, can be configured to provide all of the comfort and cleanliness we desire with a minimum of water and energy usage.

One such shower I have used and tested has a total flow rate of ½ gpm. It is a complete shower system in that it contains its own one-gallon water heater, with water maintained at 190°F, a thermostatic mixing valve, and a source of high-velocity air. The air and warm water from the thermostatic valve are mixed in a special head to provide an even flow pattern for the bather. The bathing temperature is pre-set by the user, and a simple on-off control activates the water and air.

The average water use by a group of test subjects using this shower was under 1-1/3 gallons of water. The use of showers such as this could easily effect an 80 percent to 90 percent saving in both the energy and water normally required for bathing and reduce the overall household use of water by at least 25 percent.

It is fairly reasonable to assume that, if we can shower from a one-gallon tank, we could also easily utilize it as a wash basin. I'm confident you will all see bathrooms of the future with this configuration.

While the water used for cooking is a small fraction of the total daily usage, we have found that the simple use of a small "point-of-use" heater in the kitchen can reduce both the energy and water consumption for these duties by 35 percent or more. The small heating system heats ½ gallon of water to 190°F and maintains it at this temperature. The user need not run the hot water pipes until hot water appears, which is the largest single waste in the kitchen. Instant hot water is available for the preparation of any number of foods, and only the water needed is used without any waste.

There are also other systems that can provide reasonable amounts of hot water to all of these locations without the necessity of even a small storage tank. Figure 1 shows such a system. The water heater is an instantaneous in-line type that heats the water as it flows. Power is consumed only when the water is flowing. Each water user could have its own small unit or share one with another user. These heaters have fairly large instantaneous power draws, but overall efficiencies that approach 98 percent. They also serve to reduce wasted water since hot water is available immediately.

A review of my discussion so far will show that in none of my examples is there a hot water line originating from a central water heater.

I am convinced that future domestic water systems will consist of single cold-water distribution lines, pressure-regulated, with each water user or appliance having its own hot water source. The water users will be restricted in flow, but provide ample water for their purposes; they will forgive and compensate for our bad habits, and they will still provide us with the best living conditions in the world. The technology and hardware to accomplish all of this exist today; only the commitment is needed.

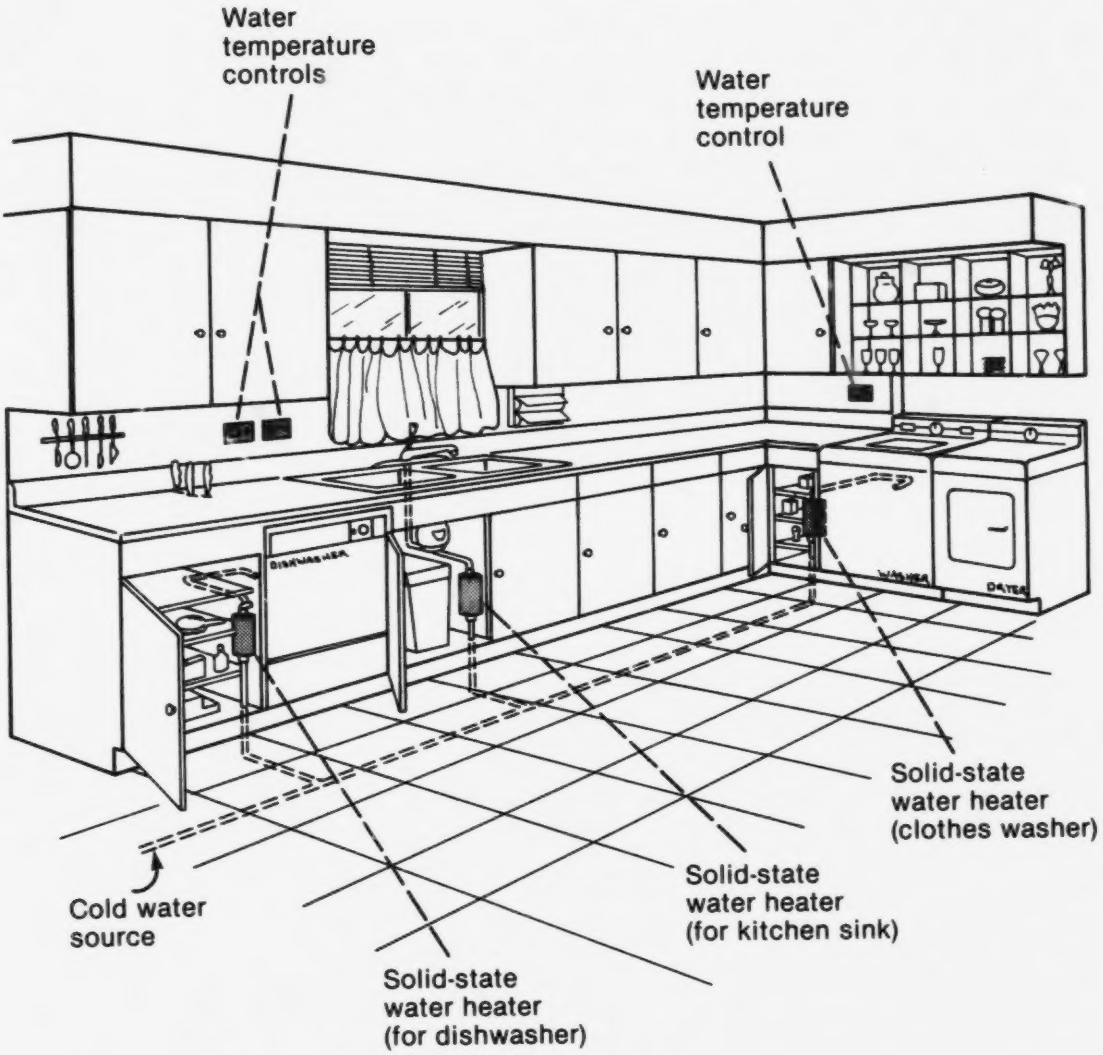
Water temperature controls
Water temperature control
DISHWASHER
WASHER
DRYER
Solid-state water heater (clothes washer)
Solid-state water heater (for kitchen sink)
Cold water source
Solid-state water heater (for dishwasher)

Figure 1. Kitchen Water Heating System.

The Role of Water Conservation in the Construction Grants Program

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INTRODUCTION

A little over a year ago, water was in critically short supply in California and several other areas; future shortages are likely to occur in these areas and others. To illustrate the dimensions of our problem: as a nation, we are using approximately 400 billion gallons of water/day (gpd), and that figure is expected to double by the end of the century. Drinking water demand is projected to increase from 30 billion to 50 billion gpd. Mother Nature cannot always be relied upon to meet these needs. For a two- or three-year period prior to 1977, drought was suffered in the Midwest, California, and some previously unafflicted areas of the nation, including the Great Lakes region and all or parts of the States of Michigan, Indiana, Virginia, Wisconsin, and Minnesota. In the mid-1960's, severe, prolonged drought was experienced throughout the Northeastern United States.

The water supply shortages and increasingly high costs of providing new water supplies and wastewater treatment have forced the Administration to reconsider national programs impacting water resources, their policy implications, and potentials for enhancement and protection of water supplies.

In his 1977 environmental message, President Carter directed that a study be undertaken leading to a comprehensive reform of water resources policy with water conservation as the policy's cornerstone. In June of 1978 the President sent to Congress water policy initiatives designed to:

- Improve planning and efficient management of Federal water resource programs to prevent waste and to permit necessary water projects which are cost-effective, safe, and environmentally sound to move forward expeditiously

- Place a new national emphasis on water conservation

- Enhance Federal/State cooperation and improve State water resources planning

- Increase attention to environmental quality.

On July 12, 1978, the President directed EPA and the Departments of Agriculture, Commerce, and Housing and Urban Development to:

- Review agency grant and loan programs for municipal water supply and wastewater treatment systems and modify those programs to remove any disincentives to water conservation
- Require appropriate community water conservation programs as a condition of such loans and grants
- Apply water conservation modifications to all loans and grants awarded after September 30, 1979.

Congress also acted to encourage water conservation. Section 21 of the 1977 Clean Water Act requires that EPA, in approving the amount of reserve capacity for a treatment works, take into account efforts to reduce the flow of sewage and unnecessary water consumption.

Acting under the authority of the new Clean Water Act, EPA did not await the President's directive but took immediate initiatives to incorporate water conservation in revising its Construction Grants Program regulations. The benefits from conservation in alleviating the shortages and producing additional monetary as well as energy resource savings outside of the Construction Grants Program were not overlooked during the development of the cost-effectiveness guidelines. EPA recently published these guidelines as part of the construction grants regulation package.

GUIDELINES

The cost-effectiveness guidelines require evaluation of flow reduction measures as part of the cost-effectiveness analyses presented in facility plans and provision for a practicable, cost-effective flow reduction program. The flow reduction guidelines apply, and the facility plan must address flow reduction alternatives unless the average daily base flow from the area is less than 70 gallons per capita per day (gpcd), or the current population of the applicant municipality is under 10,000, or the area is exempted by the Regional Administrator of EPA for having an effective existing flow reduction program. Public education, pricing, and regulatory approaches must be considered. Based upon analysis of the data reported in the 1976 Needs Survey, the guidelines will apply to about 1,200 treatment facilities serving a 1978 population of 88 million persons and about 7,500 smaller facilities serving a 1978 population of 20 million persons will be exempted.

The guidelines require a cost-effectiveness evaluation of water pricing charges, water meters, retrofit of plastic toilet dams and low-flow shower heads in existing homes, and changes in laws, ordinances, or plumbing codes to require installation of water-saving devices in future dwellings. Such an evaluation encompasses all costs of the proposed flow-reduction program, including administrative costs and the prospective energy and water supply savings, as well as those savings attributable to wastewater management. The grantee is expected to develop a recommended flow-reduction program, featuring a public information program, plus cost-effective measures for which the grantee has implementation authority or for which he can obtain cooperation from an entity with such authority. Finally, the grantee must take into account in the design of the treatment works the flow reduction estimated for the recommended program.

POTENTIAL HOUSEHOLD SAVINGS

Potential savings of money, water, and energy may be realized for typical households from the installation of cost-effective water-saving devices. These water conservation savings cover two household groups: retrofitted households and new households. The following calculations assume an average of three and one-half persons per household in each group.

The hypothetical retrofitted household has three toilets with five-gallon tanks, each fitted with a set of 1.5-gallon displacement dams, and two showers, each with a fine spray shower head. The calculation of hot water heating energy requirements assumes that shower usage requires 50 percent of the water heated to a temperature of 145°F, with the remaining 50 percent remaining at an average water supply temperature of 60°F.

Table 1 shows that the total household water use of 210 gpd would be reduced to 161.2 gpd, representing a water use reduction of 48.8 gpd. Of this water savings, less water for toilet flushing accounts for 25.2 gpd and reduced shower water for 23.6 gpd. The energy reduction corresponding to the 11.8 gpd decrease of hot shower water approximates 8400 BTU/day, before consideration of hot water heater service efficiency. After considering service efficiencies for water heaters (gas,0.5; oil, 0.45; electric, 0.8), the nationwide mix of hot water heaters (gas, 60 percent; oil, six percent; electric, 31 percent; no heater, three percent), and the heat losses in electricity production, the heat energy saved per household averages 21,400 BTU/day.

Assuming, after deducting the small costs of the conservation devices, a water charge of $1/1000 gallons and sewer charge of $1/1000 gallons, the annual household water and sewer charges would be reduced from $153/year to $122/year, representing a savings of $31/year. It is important to note, however, that this calculation assumes that water and sewer charges remain constant. If a large number of households within a community decided to conserve water, prices would likely increase, because of the need to recover the relatively large proportion of fixed costs for water and sewerage services.

The monetary savings derived from energy savings reflects assumed natural gas, oil, and electricity prices of $0.236/therm, $0.45/gallons, and $0.375/kilowatt hour, respectively. Based upon these energy prices, shower head flow restrictors will save the average household $23/year.

TABLE 1. POTENTIAL RETROFIT SAVINGS IN A TYPICAL SUBURBAN HOUSEHOLD*

Functions and fixtures	Percent of total water use	Device	Percent savings from device	Water use without device, gallons per day	Water use with device, gallons per day	Incremental cost of device	Annual cost of device**	In-house energy savings
Toilets (5 gal.)	40%	displacement dams	20%	84	58.8	3 @ $4.00 each	$2.18	no
Bathing (1/4 bathtub, 3/4 shower)	30%	fine spray shower heads	50% of shower only	63	39.4	2 @ $6.00 each	$2.16	yes
Laundry	20%	none	0%	42	42.0	---	---	---
Culinary and miscellaneous	10%	none	0%	21	21.0	---	---	---
TOTALS	100%			210	161.2	$24.00	$4.34	

* (60 gpcd x 3.5 persons = 210 gpd)

** Assumed seven-year life and 6-3/8% interest.

ANALYSIS

1. Annual savings = water charge savings + sewerage charge savings - device cost.
2. Water supply charges + sewerage charges are assumed = $2.00/1,000 gal.
3. Annual savings per household = $2.00/1,000 gal x 48.8 gal/day x 365 days/year - $4.34 = $31.28.

The following tabulation summarizes potential annual resource and cost savings per household from retrofit of water-saving devices:

	Resource Savings		Annual Cost Savings
Water/Sewer	48.8 gpd		$31
Energy	21,400 BTU/day		$23
		TOTAL	$54

New households could be equipped with 3.5 gallon/flush toilets instead of five gallon/flush toilets, fine-spray shower heads, aerated kitchen and lavatory faucets, and water-conserving automatic clothes washers and automatic dishwashers.

Table 2 shows a total household water use reduction of 74.2 gpd for the new household equipped with water-saving devices. The energy saved by the new household, based on the reduction in use of 22.8 gpd of hot water, amounts to 16,700 BTU/day, before consideration of hot water service efficiency. After consideration of service efficiencies, the national mix of hot water heaters, and the heat losses incurred in electricity production, the heat energy saved averages 40,700 BTU/day.

The total monetary costs for water/sewer for new households would be reduced from $153/year to $101/year, representing a savings of about $52/year. The monetary savings from the household energy reduction of 40,700 BTU/day averages $44/year. Potential annual resource and cost savings per household are:

	Resource Savings		Annual Cost Savings
Water/Sewer	74.2 gpd		$52
Energy	40,700 BTU/day		$44
		TOTAL	$96

POTENTIAL NATIONWIDE SAVINGS

The following analyses develop estimates of the potential savings of water and related water management costs, including those for water supply and wastewater treatment, attainable from an aggressive nationwide water conservation program. The estimated savings include the reduction of household energy use and related costs resulting directly from water conservation measures.

TABLE 2. POTENTIAL SAVINGS FROM DEVICES INSTALLED IN A NEW SUBURBAN HOUSEHOLD*

Functions and fixtures	Percent of total water use	Device	Percent savings from device	Water use without device, gallons per day	Water use with device, gallons per day	Incremental cost of device	Annual cost of device**	In-house energy savings
Toilets (5 gal.)	40%	3.5-gal. flush tank	30%	84.0	58.8	0	0	no
Bathing (1/4 bathtub, 3/4 shower)	30%	fine spray shower heads	50% of shower only	63.0	39.4	0	0	yes
Automatic clothes washer	17% (35 gal/ load)	18-gal/ load washer	50%	35.7	18.0	0	0	yes
Kitchen and lavatory faucets	7%	spray on lavatory faucets	20%	14.7	11.8	$10.00	$1.82	yes
Automatic dishwasher	6% (12 gal/ load)	7.5 gal/ load	38%	12.6	7.8	0	0	yes
TOTALS	100%			210.0	135.8	$10.00	$1.82	

* (60 gpcd x 3.5 persons = 210 gpd)

** Assumed seven-year life and 6.38% interest.

ANALYSIS: Annual savings per household = $2.00/1,000 gal. x 74.2 gal/day x 365 days/year - $1.82 = $52.35,

Potential Water Management Savings

Applying the previously derived household retrofit savings of 48.8 gpd/household (23 percent of household use) to the average wastewater flow of 63 gallons/capita for residential and commercial purposes gives an average flow reduction of 14.5 gpcd. The nationwide flow reduction through retrofit, based upon the estimated 1978 population of 144 million persons served by wastewater treatment facilities, therefore approximates two billion gpd. Water-saving devices and appliances installed in new homes and commercial establishments, saving 22.3 gpcd for a population growth increment of 88 million persons between 1978 and 1990, could save an additional two billion gpd by 1990. Accordingly, potential water savings through retrofitting and new home installation could total four billion gpd by 1990, compared with the total present wastewater flow of 25 billion gpd.

The estimated nationwide savings in capital costs for water supply facilities reflect only the foregone capital costs of new or expanding supply facilities including pumping, storage, and water treatment. Application of these costs, roughly estimated at $0.60/million gpd, to the total water savings of four billion gpd by 1990 results in a total capital cost saving for water supply facilities on the order of $2.4 billion in 1978 dollars.

The 1976 Needs Survey estimate for wastewater treatment costs totals about $34.2 billion in 1976 dollars. Since the construction cost equivalent of funds obligated since that time approximates $6.8 billion, the remaining need is about $27.4 billion in 1976 dollars or $31.1 billion in 1978 dollars.

This analysis assumes that flow reduction will reduce costs of only the preliminary treatment, pumping, primary settling, chlorination, and effluent outfall facilities in a typical activated sludge treatment plant because the sizing and costs of other units depend primarily on pollutant loadings rather than flows. About 25 percent of the $31.1 billion treatment plant estimate is assumed to be for plant expansion or upgrading not involving substantial changes of the flow-dependent facilities listed above. Thus, only 75 percent of $31.1 billion, or $23.2 billion, would be affected by water conservation. The 1976 Needs Survey indicates that $18.8 billion of the $23.3 billion estimate would be attributable to the backlog of existing needs, and the remainder ($4.5 billion) represents reserve capacity for the growth projected to the year 1990.

Based upon 1976 Needs Survey data, average flows used for treatment plant design are:

Industrial flow		19 gpcd
Nonexcessive infiltration/inflow		24 gpcd*
Commercial plus seasonal peak flow		13 gpcd
Residential flow		50 gpcd
Treatment plant design flow	TOTAL	106 gpcd
Excessive infiltration/inflow (I/I)		24 gpcd
Flow before I/I removal		130 gpcd

* Assumed to be one-half of total existing infiltration/inflow of 48 gpcd.

Applying the 14.5 gpcd retrofit flow reduction to the backlog estimate of \$18.8 billion and relating the 22.3 gpcd figure to the reserve capacity estimate of \$4.5 billion, the composite flow reduction can be calculated as:

$$\frac{(\$18.8 \text{ billion} \times 14.5 \text{ gpcd}) + (\$4.5 \text{ billion} \times 22.3 \text{ gpcd})}{\$23.3 \text{ billion}} = 16.0 \text{ gpcd}$$

The composite flow reduction of 16.0 gpcd corresponds to a treatment plant design flow reduction of 15 percent.

Based upon EPA research into construction costs for municipal wastewater treatment facilities, the construction cost estimate for the various unit processes and components in a typical 10 mgd activated sludge plant totals \$13.96 million in 1977 dollars, of which \$2.88 million represents the estimated cost total for preliminary treatment, influent pumping, sedimentation, and chlorination. Using an economy of scale factor (x) of 0.9, the design flow reduction of 15 percent would reduce the \$2.88 million cost figure by 13.6 percent. The economy of scale factor (x) appears in the familiar cost equation, $C = KQ^x$, where C is capital cost and Q represents flow. Of the \$13.96 million cost for the typical plant, \$1.73 million is for the effluent outfall. Using an economy of scale factor of 0.4 for the pipe, the 15 percent design flow reduction would produce a 6.3 percent outfall cost reduction. The composite cost reduction for the plant is:

$$\frac{(\$2.88 \text{ million} \times 13.6\%) + (\$1.73 \text{ million} \times 6.3\%)}{\$13.96 \text{ million}} = 3.59\%$$

Multiplying the 3.59 percent reduction in treatment plant costs by the \$23.3 billion estimate for treatment facilities affected by water conservation gives a potential cost reduction due to water conservation of about \$836 million for wastewater treatment facilities needed by 1990. This is 2.7 percent of the total need of \$31.1 billion in 1978 dollars for treatment facilities, both affected and unaffected by conservation measures.

Dr. Wen Huang, in an unpublished paper, has calculated pipe (interceptor and collection system) cost reductions attributable to water conservation based upon pipe size and unit price data collected during the 1976 Needs Survey. Based upon an assumed 30 percent reduction in domestic flow, he found that the pipe design flow reduction would be 22.2 percent. He counted savings only where the 22.2 percent flow capacity reduction was found sufficient to permit use of the next smaller available pipe size. No cost savings were counted for all proposed eight-inch collector pipes, as this was assumed to be a minimum size. Dr. Huang estimated cost savings for interceptors and collectors at \$1.27 billion in 1978 dollars. The design capacity reduction based on the potential flow reductions calculated herein is 18.7 percent. Adjusting Dr. Huang's estimate accordingly gives a pipe cost savings of \$1.05 billion.

In summary, the potential capital cost savings for wastewater treatment works and pipes attributable to water conservation measures follows:

		Capital Cost Savings (billions of 1978 dollars)
Treatment facilities		0.8
Pipes		1.0
	TOTAL	1.8

Energy Savings

The nationwide energy savings are based on the 1978 resident population of 144 million persons who are served by wastewater treatment plants and who achieve a retrofit savings of 21,400 BTU/household/day and upon an average household size of 3.5 persons. These retrofit household savings translate to a heat energy savings of 0.9 x 10^{12} BTU/day. Water conservation in new households is based on the increase in resident population served by wastewater treatment plants who achieve a household heat energy savings of 40,700 BTU/day and upon the same average household size of 3.5 persons.

By 1990, the energy savings are increased by 1.0 x 10^{12} BTU/day to potentially 1.9 x 10^{12} BTU/day. Based upon the incremental cost of fuels reported earlier, the potential accrued savings by 1990 due to energy conservation are $19.5 billion.

Summary of Natural Resource and Cost Savings

The estimated potential water, energy, and cost savings accruing between the years 1978 and 1990 based on the nationwide water conservation program described herein are:

	Resource Savings	Cost Savings (billions of 1978 dollars)
Water/Sewer	14.6 trillion gal	4.2
Gas	3 trillion ft^3	
Oil	60 million bbl	19.5
Electric	296 billion kwhr	
Total Cost Savings 1978 - 1990		23.7

OTHER EFFECTS OF WATER CONSERVATION

In November of 1977, a team from the Facility Requirements Branch of EPA visited five utility districts in California to learn firsthand about major water conservation programs and their effects. They found that the recent drought had no discernable effect on employment or local development. Conservation programs reduced water consumption and wastewater flows dramatically, thereby permitting development to proceed and business to operate.

Wastewater flow reductions ranging from 25 percent to over 60 percent were achieved.

The team found that substantial flow reductions on the order of 30 percent could be achieved without any reduction in the efficiency of treatment facilities or any significant problems in sewage conveyance. Larger reductions did create problems, particularly with sewage becoming septic before it reached the treatment plant. This required the addition of chlorine or hydrogen peroxide for odor control. Of most importance, the team reported that where flow reductions were less than 30 percent, increased recirculation of wastewater could compensate for plant influent reduction and increase the retention time in the activated sludge units. Increased plant efficiency resulted as reflected in the reduced mass emissions of BOD and suspended solids.

CONCLUSION

If viewed from the narrow context of wastewater treatment alone, the treatment works cost savings attainable from water conservation are limited. From broader water management and resource conservation perspectives, however, the resource savings, monetary cost reductions, and other benefits are real and of significant proportions. Not to be overlooked, the increased treatment plant efficiency attainable from water conservation will reduce mass emissions of pollutants and, as a result, enhance water quality.

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Guidelines for Planning a Citizen Participation Program

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Planners and decisionmakers in cities, towns, and regions throughout the country have been struggling to find positive ways to incorporate citizen participation into their plans and decisions, and in many cases they have become discouraged when citizen participation brings more pain than progress. Perhaps this reaction stems from the fact that citizen participation has too often been the tail wagging the donkey.

Almost all public decisions in a city or region that set policy for water quality, water conservation, or wastewater management are preceded by a lengthy and complex planning process during which professionals explore the problems, gather technical information, analyze the information, develop alternative strategies, and finally recommend a favored plan.

If citizen participation is to be a genuine part of the planning and decisionmaking process, then it must be regarded as seriously as the technical or scientific elements of planning. This requires a conscious effort to prepare a "citizen participation work program" with its own set of tasks, activities, schedule, budget, staffing, and evaluation procedures.

There are no specific guidelines for determining how much citizen participation should be sought on any particular issue. Obviously a complex issue involving a diverse population with competing uses of land, water resources, and financial resources has a significant potential for creating conflict. This situation requires a larger investment in participatory planning than would a fairly simple issue with little potential for conflict. The size, geographical spread, and characteristics of the population, the complexity of the issue, and the resources available are all important considerations in designing citizen participation programs.

The first steps in planning an effective citizen participation program are to clarify the parameters of the planning or decisionmaking process, determine when communication with citizens should and can occur, set objectives for the program, and develop an understanding of the critical issues and concerns the public expects to see addressed. Once the planning team has developed a basic awareness of the issues and the people to be involved, those people managing the community involvement program can select the communication methods and activities that will be most productive in reaching people of all points of view in each community. However, if there is confusion or disagreement among the team with regard to the fundamentals, the program may eventually fail.

The following guidelines may be helpful to planning and designing a citizen participation program tailored to a specific problem situation.

- Analyze the planning process for important steps and decisions

- Develop a community profile and description of issues and concerns

- Clarify information needs

- Select appropriate communication and involvement methods

- Determine a process for documenting and using public input

These guidelines provide a framework for preparing a work program which will assure that each method of providing information and generating citizen participation will be successfully implemented and that adequate staff and budget have been allocated for the program. A detailed list of tasks required to implement each method should be developed along with a schedule for activities planned to fit within the time requirements of the entire planning and decisionmaking process. The role of each member of the planning team should be made clear prior to initiating the program. Many agencies assign one staff member to manage the entire program to assure consistency and coordination.

Procedures for evaluating the program should be determined to monitor the effectiveness of each activity as it is initiated. Since it may be impossible to foresee all the needs for communication and interaction with the public that may be required during the process, a certain amount of flexibility in the program is necessary in order to respond to problems as they arise.

Guideline 1: Analyze the planning process for important steps and decisions

- Review the planning or design process
- Determine critical points for public interaction
- Agree on objectives for the citizen participation program

In order for citizen participation to be integrated into each step of the decisionmaking process, the agency team members responsible for the citizen participation program should become familiar with all elements of the plan or study, review with one another the timing of each phase of the planning process, and determine when certain information from the public should be available for use in the process. This is also the appropriate time to develop a team agreement on the goals and objectives of the citizen participation program. A high level of commitment to the objectives of the program is necessary from both staff members and agency managers and administrators.

Guideline 2: Develop a community profile and description of issues and concerns

- Develop an informational profile of all affected/interested communities and groups
- Identify major issues and concerns of each community and group

Before selecting the methods to use and allocating staff time and other resources to the effort, the agency team needs to develop an initial amount of information about the affected public and the level of concern and interest the public has in the issue under consideration. The first step is to develop a list of the groups and individuals with whom the agency may wish to communicate during the process. This should include lists of all affected neighborhoods and neighborhood associations, local governmental bodies and the elected and appointed officials of these jurisdictions, all boards, commissions and committees that may have an interest in the issue, and all interested groups and organizations -- civic, special interest, business, industry, and labor. This information also provides the beginning of a mailing list.

Demographic and social information should be gathered to understand characteristics of each segment of the public and to assess how best to communicate with and involve each segment or group.

It is useful at this time to conduct brief interviews with a selection of community leaders and residents to assess the amount of interest in the issue and identify the related issues and concerns that may need to be addressed during the process. This information should be shared with the agency team and used to plan each phase of the citizen participation program.

Guideline 3: Clarify information needs

- Identify information about the issue needed by affected/interested communities and groups
- Identify information needed by the agency team from the public

From the information gathered through this preliminary field work, the agency team can outline the type and amount of information that the public will need to be provided with during the process and identify what kind of information the team requires from the public in order to clarify the problem, develop alternatives, and make a final decision. A team discussion of information needs will help each technical expert on the team determine what data may be useful to provide to the public, and how the agency can present the technical information in a clear, concise, and relevant manner to the people who will receive it. Enough information should be provided to the public so that citizens can understand the issues, alternatives, and impacts and can make informed judgements. This team discussion will also clarify how the information received from the public will be used.

Guideline 4: Select appropriate communication and involvement methods

- Select methods for providing information to the public
- Select methods for public participation in each phase of the process

With the information developed in the above three steps, the agency team is now prepared to outline a citizen participation program and select the communication and involvement methods that are appropriate to each phase of the planning or decisionmaking process. A range of methods should be considered, including public meetings and workshops, surveys, small group meetings, personal interviews and discussions, directly mailed interviews or brochures, use of the mass media, and the formation of citizen advisory committees and task forces. Several of these methods can be used at the same time to ensure broad communication and involvement.

Guideline 5: Determine a process for documenting and using public input

- Clarify the use of public input at each phase of planning and decisionmaking
- Determine method and timing for reporting public input to planners and decisionmakers

The agency team should agree on the methods for documenting the information received from the public, reporting the information, and evaluating its significance. The values, goals, concerns, and opinions expressed by the citizens at each phase in the planning process should be carefully recorded and communicated by the agency team to the decisionmakers. This documented information should also be available to the public.

These guidelines and the work program developed from them will assure that the information generated by the community will be used in the problem-solving process along with technical and scientific information, to:

- Define and clarify the problem from all points of view
- Develop ideas for alternatives
- Evaluate alternatives
- Select a final plan of action

The success of a citizen participation program should be measured against the objectives of the program and the individual methods used to achieve these objectives.

The tables included in this section suggest a set of six objectives for citizen participation that are appropriate to most planning and decision-making processes, and methods that can be used to achieve these objectives. The amount of time, energy, and resources devoted to achieving each objective must be based on each different situation. The tables also suggest questions and criteria that can be used to evaluate the methods and objectives. Some of the criteria for evaluation can be based on quantifiable information while other criteria must be based on more subjective data, such as professional and citizen judgement.

These tables are not meant to be all-inclusive. Criteria for evaluating citizen participation are in their infancy. An overall measurement of success is whether planners and decisionmakers have enough information about public attitudes and priorities to provide reasonable assurance that final plans, programs, or policies are politically feasible, economically desirable, and socially acceptable.

This approach, along with information about state programs for citizen participation, can be found in the recently published "Techniques of Public Involvement," as part of The State Planning Series, published by the Council of State Planning Agencies.

IDENTIFY THE PUBLIC

Objective: Identify the public to be involved in the planning and decision-making process, including all neighborhoods, local jurisdictions, groups, and organizations.

METHODS	QUESTIONS FOR EVALUATION	SUGGESTED CRITERIA FOR EVALUATION
Map study area Analyze existing community data: Demographic Political Social Economic	Can the agency identify the specific geographic areas as well as special interest groups and organizations that comprise the public to be involved?	Documented list of groups, organizations, individuals, and households notified in some manner during the involvement process.
List names and addresses of interested groups, organizations, leaders, and officials.	Can the agency identify groups within the general public who were not notified or offered an opportunity to participate?	Number and content of complaints made by groups or individuals not notified or involved in the program.
Talk to local citizens, leaders, and officials.	How representative of the general public or range of viewpoints were the groups and individuals who participated in the process?	Profile of demographic, social, and organizational characteristics of the general public compared with a profile of participants in the program (workshop attendees, survey respondents, committee members, etc.).
		Staff judgment.

PROVIDE INFORMATION

Objective: Provide the public with adequate and continuous information throughout the decisionmaking process about the problem or need and the effects of alternative solutions.

METHODS	QUESTIONS FOR EVALUATION	SUGGESTED CRITERIA FOR EVALUATION
Media: Television Newspapers Radio	How many people were reached through the media?	Media readership or viewership statistics.
	Was the content of the media information relevant, concise, and understandable?	Selective sample to determine response to media or direct mail.
Printed material -- mailed or handed out: Newsletters Brochures Reports Notices/Fliers	How many groups, individuals, or households received the printed material?	Mailing lists used.
		Comments from individuals and groups on the mailing list.
	Was the content of the printed material relevant, concise, and understandable?	
Presentations at: Public meetings Public workshops Briefings Small group meetings Public hearings		Written questionnaire and oral feedback from audience.
	How many people attended the workshops, briefings, and meetings?	Evaluation by citizen advisory committee.
	What was the response of people to the presentations?	Staff judgment.
Displays: Posters Information Centers	How much confusion, lack of information, or misconception of the issues seems to exist after dissemination of information among different groups or individuals?	

RECEIVE INPUT

Objective: Provide the public with appropriate forums for input into all phases of the planning and decisionmaking process including opportunity to be involved in:

- defining the problem or need
- providing information
- developing alternatives
- evaluating alternatives

METHODS	QUESTIONS FOR EVALUATION	SUGGESTED CRITERIA FOR EVALUATION
Meetings: Public meetings Public workshops Briefings Small group meetings Public hearings	Was the notification method for meetings adequate to encourage broad attendance by the target public? Did the meeting process produce clear and appropriate feedback from all participants?	Analysis of meeting participants through use of registration cards: Where they live What groups they represent
Personal interviews and discussions with: Local officials Citizen leaders Residents Groups	Was the timing and location of meetings appropriate to the needs of the target publics? Were survey respondent samples appropriate and statistically significant?	Documented results of meetings: Group discussions, questionnaires, comment sheets, transcripts Meeting evaluation by participants
Surveys and questionnaires	Were questionnaries clear and unbiased?	Staff analysis of survey sample selection, methodology, and results
Citizen advisory committees, commissions, task forces	Did the surveys or interviews seek information from the public that was useful to the process? Was the membership of advisory committees and task forces well balanced? Were the objectives clearly defined and useful? Was there opportunity for citizen input in each phase of the process? Did the staff and decisionmakers have adequate information to understand the concerns and opinions of citizens from all points of view and all geographic areas?	Comparison of demographic data from survey, meetings, and general public Analysis of how the results of each method were used in planning process General evaluation by citizen advisory committee Staff judgment

DOCUMENT, EVALUATE, AND USE INPUT

Objective: Provide complete reporting of public input in a manner that is useful to the planning process and also assures that the information received is given due consideration by agency administrators and public officals.

METHODS	QUESTIONS FOR EVALUATION	SUGGESTED CRITERIA FOR EVALUATION
Written reports of public meetings, workshops, surveys, questionnaires, and other involvement methods	Does the report indicate the results of group discussions, individual questionnaires, and oral comments?	Review of documentation format by agency staff, officials, or citizen advisory committee
	Are the results tabulated and reported in a format that can be analyzed and used in the planning process?	Comments on use of results by staff and decisionmakers
Audiovisual documentation Slides Videotape Film	Does the form of documentation help the planners and decisionmakers understand the diversity of opinion and which publics represent certain attitudes and opinions?	Staff judgment on the relevance of results to the planning process and decisions to be made Evaluation of use of results by a citizen advisory committee
	Are all appropriate agency staff members and officials provided with copies?	
	Are copies available to citizen participants and the general public?	

REPORT RESULTS

Objective: Provide a method for reporting the results of the community involvement process to the public.

METHODS	QUESTIONS FOR EVALUATION	SUGGESTED CRITERIA FOR EVALUATION
Report results in local media	Was there a process for reporting results after each phase and for each method used?	Feedback from citizen committees or task forces
Report update of results during public meetings and hearings	Were citizens aware of how these results were used in planning and decisionmaking?	Feedback from selected sample of citizens receiving the report
Report update of results at each meeting of advisory committees and task force	How many groups or individuals felt that their input was not reported?	Feedback at meetings and hearings
Mail special report to program participants		Number and content of complaints from groups or individuals
Mail special report to selected lists of public officials, leaders, groups, organizations, and individuals		Staff judgment

PROGRAM, BUDGET AND STAFFING

Objective: Provide a budget and program management and staffing to ensure that the objectives of the program can be met.

METHODS	QUESTIONS FOR EVALUATION	SUGGESTED CRITERIA FOR EVALUATION
Prepare a plan for the public involvement program including:		
Objectives	Were the objectives appropriate to meet the needs of the planning process?	Staff evaluation of results of citizen involvement program
Methods	Were the methods for involving the public appropriate to the issue and communication needs and styles of the agency and publics?	Feedback from advisory committees and program participants
Task Descriptions	Were all tasks necessary to implement the program anticipated and budgeted?	identification of tasks not anticipated or budgeted
Time Flow Diagram	Was adequate time scheduled to plan, implement, and document the program?	
Budget by Tasks	Was the budget equal to the level of effort desired?	Identification of program elements eliminated due to lack of time, budget, or staff resources
Staffing Requirements	Was staff adequate to be able to implement all tasks, in terms of numbers and professional competency?	

Mandate and/or Marketing: Implementing Water Conservation in the Private Sector

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INTRODUCTION

In examining our present approach to community water management, we note that overall, it is an extrapolation of our past policies. It relies on the rapid expansion of centralized high technologies geared to increase the supply of water and speed up the delivery process.

Are we not compelled to ask the following questions:

> Is this what we want to do?
> Can we do it with the tools we have?
> Are there other tools available?
> How can we best use all that there are?

Underlying our contemporary social and cultural consciousness is the belief that big is best and that the complexity of modern life automatically means complex organization. For some reason, the idea of "small" raises horrendous images of a return to a primitive dark age. But we cannot afford such a dismissal of possible, simpler solutions if and when they are appropriate to managing limited natural resources.

Estimates for achieving the nation's water quality goals have been put as high as $800 billion. Our confidence in assuming we have the national wealth to cope with such capital commitment may be entirely misplaced to begin with, without introducing the notion that what we are buying may be inadequate, inefficient, and harmful to future generations.

The current philosophy of building and maintaining large, centralized water supply systems and treatment mechanisms seems to be directly tied to social values; i.e., the more water we use, the cleaner we are; the cleaner we are, the better we are. It has been said that developing and Third World countries are so entrenched in the desire for social status of the Western variety that, in the arid deserts of the Arabian Peninsula, people will buy flush toilets even though they do not have the water supply to flush them.

What is the cost of this "public convenience," water?

In the United States, we have long grown used to measuring all things in dollars. Recently, the Swedes have been experimenting with methods of "energy accountancy." The equations of this concept measure the value and justification of a product, method, system, or policy by how much energy it consumes.

In this report, it is contended that the link between energy and water is not only correct in ecological and scientific senses (as in the first and second laws of physics), but, also, that there is a direct comparison and link between the two resources in determining future national, State, and local policies.

WATER: RESOURCE OR COMMODITY

Water, so long treated as a free commodity, can no longer be taken for granted. Even the most current State and Federal policies and management methods evaluate water resources as if the price of water is equal to zero. We know that this is not the case.

In determining the true cost of water, we must look to the time in the not-so-distant future when, due to depletion and contamination, ground and surface waters are no longer readily available to us. A recent report by the U.S. Environmental Protection Agency (1978) states that

> Half of the population of the United States is served by ground water...the use of ground water is increasing at a rate of 25 percent per decade...removing the source of contamination does not clean up the aquifer once contaminated. The contamination of an aquifer can rule out its usefulness as a drinking water source for decades and possibly centuries.

The future costs associated with delivering water from alternative sources must be calculated today. We must look to its price, with price being defined as: "cost" plus "rent," where "rent" is the extra charge a seller can exact because of profit, convenient delivery, high quality, political connections, monopoly, or other factors beyond the technical costs of production. We know water will become much more expensive, no matter what we do. Therefore, we must view water as we would any scarce commodity and economize in its use.

I maintain that the social, political, and economic problems which beset our current direction are so crucial that there is sufficient reason to seek new approaches to the problem. We must, therefore, seek a direction which can carefully and rationally reshape our prevailing patterns of water use. It is worth noting that wasteful consumption has been a measure of social disintegration throughout history.

THE BOSTON TEA PARTY REVISITED

In late June 1978, the Boston Water and Sewer Commission, after a year of deliberation, announced that due to new capital and operating and maintenance costs, the rate charged for use of the sewer system would be tripled. Because of delays arising from painful deliberation, the new rate is retroactively effective from the beginning of 1978. Further, two-thirds of that increase will be capital charges for renovation and new plant construction. Will the already heavily taxed citizens take lightly the prospect of an ever-increasing rate structure? In the light of increasing public outcry over a taxation system with fewer perceived benefits (i.e., the California Proposition 13 tax revolt), the high subsidy costs of water carriage waste management methods should be clearly revealed.

It should be noted that the soft path, or conservation approach, does not aim at being an oppositional force in competition with existing structures. Its purpose is to use limited resources efficiently; to devolve the systems; and to counter our overreliance on vulnerable network systems. Originally, highly centralized organization came about through having at our disposal large amounts of inexpensive resources. Circumstances have changed and so must we.

Now there is need for a prompt commitment to decentralization and innovative and alternative technologies; a dedication to efficient use of water; rapid development of a program which seeks to match water resources in scale and in quantity to the end-uses needed. This is not a radical approach which would have us do away with the old and bring in the new. On the contrary, it recognizes the value of these present systems and seeks to utilize them efficiently.

Today we have heard of many ways to solve these problems, but if we have already judged some of these technical fixes as being desirable and if savings resulting from such systems could, in fact, reduce or eliminate the need of new capital investment for additional water supply, then why, as Pogo said, do we stand here, confronted by insurmountable opportunities? Perhaps we need to identify more completely the social, political, institutional, and economic barriers that currently inhibit any change in the status quo.

The task is to refocus the public and private sectors to seek profit (economic and social) from the opportunities in appropriate alternatives.

In fact, the soft path is more in keeping with traditional American values such as thrift, self-reliance, home cooking, neighborliness, and craftsmanship. Therefore, official recognition of the conservation approach will only reinforce deeper convictions.

SUPPLY AND DEMAND

We know that the supply problem stems from the proliferation of various uses of water. Human demands for water resources compete among one another for the same water: irrigation, public drinking supply, sewage disposal, power generation, recreation, and so forth. We have to analyze basic water requirements in terms of demands, both human and environmental, which are either consumptive or nonconsumptive. That is to say, consumptive purposes such as drinking, irrigation, industrial processing, or evaporative cooling versus nonconsumptive uses such as recreation or hydropower generation.

We can see that a variety of problems immediately arises when we ask: what quality of water should be delivered for any one end-use?

Generally speaking, the water companies take the position that they should deliver the highest quality of water to all users and thereby eliminate any conflict over demand for uncontaminated supplies. But, there is no need whatsoever to deliver potable drinking water for agricultural irrigation. Nor, is the need for high quality drinking water for waste assimilation, thermal-electric power cooling, hydroelectric power industrial processing, and many other uses.

A QUESTION OF SEMANTICS

Throughout the U.S., the meaning of "water use" is a rather subtle one, requiring examination. "Use" is often defined as the amount of water which is delivered by supply systems or otherwise withdrawn from available resources through private wells and surface water supply.

The interlinking of supply and demand and using the two words synonymously is one of the major failings of water policy today. Focusing primarily on water that must be supplied rather than on that which is regularly consumed by the public begs many questions relating to end-use efficiency and water resource management. This reintroduces a basic tenet of the logic behind this paper; i.e., the differentiation between a hard and soft path approach.

THE HARD AND SOFT PATHS OF WATER MANAGEMENT

The hard path of water resource management calls for developing increasingly larger amounts of supply through inter-basin transfer, major stream flow diversions, etc., to meet increasing demand. This notion arises from the perspective of historically entrenched interests who comprise the supply end, such as the centralized water and sewer commissions who are responsible for delivering water supply and related trade and professional groups, such as the American Water Works Association. This particular hard path approach presupposes a continued expansion of water resources, water demand, and consumption. But key indicators tell a different story.

We see that in the industrial sector, water usage is actually turning down. Nonetheless, statisticians continue to report an increase in water demand on an annual basis where, in fact, this may no longer be the case. Further, it need not be the case. By combining energy conservation and water conservation, the demand for water should be reduced because of the consumer's desire to spend less of his financial resources heating water that goes down the drain.

THE ECONOMICS OF HOT WATER: A MARKETING OPPORTUNITY FOR WATER CONSERVATION

We should consider the present-day facts of hot water economics. By linking the energy and water issues, we can increase public awareness of water as an economic resource, and the consumer is willing to reduce overall demand by conservation and more careful assessment of end-use requirements.

Flow reduction brings the management of water and energy resources together in a team effort which serves both objectives exceedingly well. This combination provides a unique opportunity not only to recover the costs directly associated with fresh water supply and wastewater treatment but at the same time reduce the demand for fossil fuel.

The search for alternatives to an increasing dependence on imported petroleum products leads us to develop new energy technologies. We are becoming more familiar with the word "payback;" i.e., the rate of time in which an initial investment is returned in dollars saved by reduced fuel demand. Solar heating systems return their initial investments in eight to 12 years; insulating a house, three to five years.

Increasingly, consultants in their search for more cost-effective ways of plugging energy leaks are discovering that energy and water conservation are so intimately entwined that any reduction in the usage of water will automatically result in the reduction of energy usage. If less water is used, less pumping is required to transport the water, so less energy is consumed. If less hot water is used, less fuel is required to heat the water.

The average American is, for the most part, unaware of the economic cost of water. Federal subsidies and previous water supply policies give the appearance that water is, for all practical purposes, free. Few of us are familiar with the recent U.S. Environmental Protection Agency data which indicate that the true capital costs for water supply and wastewater treatment can be as high as $10/1,000 gallons (and that is without a resource depletion allowance, as is the case for fossil fuels). But, even so, $10/1,000 gallons means little to someone earning a week's pay because that figure is buried in his tax rate. However, if that wage earner has an electric hot water heater, it costs him $12/1,000 gallons to heat his water. All that money is spilling into the sewer day after day, and the cost is coming directly out of his pocket, not Uncle Sam's. Tell him such facts, and, the next thing you know, he has a bucket measuring the flow rate of his showerhead to find out how many dollars he loses per minute while his teenage son spends a half hour in the shower relaxing after a hockey game. Because that's his hard-earned money. Suddenly, water is an economic commodity which he will conserve because that cost has become very real to him. The very same awareness in a college president, hotel owner, or State housing authority translates into thousands, then millions of dollars saved annually.

These savings are the prime motivation for water conservation in the private sector today. When installing low-flow showerheads and low-flow faucet fixtures, the payback on investment is so rapid that often, for a hotel or a university, the fixtures are paid for in fuel savings before the purchase funds are given over to the supplier.

For a Federal water management program that works through State and local government, this means spearheading a local program where much of the cost is recovered by future energy savings coupled with reduced water supply and treatment costs. The entire conservation program could be self-funded, and moreover, become a profit center for the community which could itself market the vendable products and services where appropriate.

The benefits of such a program are especially pronounced in the Northeast, where heating fuel costs are higher than in other parts of the country. In addition, costs for water supply and treatment are also higher, due to extensive industrial and municipal pollution.

Communities who undertake such water conservation programs may well have all the civic, social, and educational resources necessary to do the job, with minimal need for State or Federal assistance, thus fostering greater self-sufficiency.

ENGINEERING ECONOMICS AND DESIGN: A NEW APPRAISAL

Let us assume we can decrease the water consumption in a building and examine how this affects the energy demand.

When water demand is decreased, the diameter of the piping is decreased. Smaller size piping requires less insulation bulk. Diminished piping and insulation use up less materials, thus less energy is consumed in their procurement and manufacturing. Decreased water demand will result in smaller pumps that require less energy. Less material will be required for their construction also. Less hot water demand requires less fuel, smaller heaters, and, again, smaller piping and amounts of insulation. Heat loss will decrease from the resulting reduced surface areas. Water conservation in all buildings will decrease the demand on municipal supply systems, creating energy savings in pumping and water treatment. Decreased water demand will result in less sewage flowing to the sewage treatment plant, again resulting in considerable energy savings.

All of this necessitates a reexamination of design criteria as applied by the plumbing and engineering professions. These criteria need to be defined by the facts of modern life: conservation of materials. prevention of water supply pollution, and energy conservation.

The basis for practically all our plumbing design criteria was established more than fifty years ago by research at the National Bureau of Standards. We are still designing systems based upon half-century-old criteria. Major improvements in the design and manufacture of fixtures, faucets, valves, equipment, and materials have occurred in the last decade. Yet the majority of those improvements seem to be completely ignored in our calculations and designs, despite the potential impact of the most commonplace appliances. According to a recent journal (Energy and Buildings, 1977),

> The technologies which control how energy is used in buildings are essential elements of those buildings...the architect must recognize, seek out, and even develop if

necessary those technologies which will permit his building to deliver human benefits at minimum human cost. Above all, he must avoid dismissing a technology, approach, or piece of hardware because it appears on the surface to be too simple or insignificant. We tend to be enthralled by highly sophisticated technology, being so impressed by its cleverness that we fail to appreciate how small is its net efficiency.

Showerheads have been designed which produce an intense fine spray while sharply restricting the quantity of water. One will save approximately 100 liters (26 gallons) of water during an eight-minute shower. If the incoming water temperature is 45°C (113°F), the use of this showerhead will save 3.7 kilowatt-hours (kWh) per shower when compared to a conventional showerhead. A 1,000 megawatt generating plant will produce approximately 5.0 x 10^9 kWh per year. This is roughly the equivalent to the total amount of energy which would be saved if 3.7 million of the water--saving showerheads were installed in dwelling units having electric hot-water heating. The cost of a 1,000 megawatt generating plant (nuclear) is now in excess of $1 billion. In other words, $37 million invested in showerheads would make the nuclear plant unnecessary. These represent capital costs only. In addition, of course, the operating expenses to produce a savings from the showerhead are zero as compared with the operating expenses required to produce the output from the new generating plant.

CONSERVATION VS. GROWTH: CATCH-22

The main component in any demand equation is the rate at which total use of water is expected to increase. Here we have perhaps the most important aspect of all.

For utility companies, the projection of demand (and therefore, revenue) is a key factor in determining the quality of the investment security and debt instruments that these institutions use to finance expansion, operation, maintenance, and replacement capital costs. Therefore, if projections should turn down, this may indicate that there are defections from the utility networks. The utilities' cash flow would sustain damage, as would State and municipal budgets dependent on those utility tax revenues. All of this is very unsettling to the Wall Street community, where investment risk is calculated on the certainty of future revenues divided by the costs incurred to generate them. If projected utility or municipal revenues turn down, the ratings of the securities are also downgraded. The capital base is reduced because investors move their funds to other, more secure investments, and a negative spiral of disintermediation begins. Soon the financing utility finds it impossible to continue without massive intervention from State and Federal government. Now, we can see the catch-22 of the capital markets where growth (here, in the form of increased water demand) is needed to sustain the investment base. If conservation is practiced, the utilities will be forced to increase prices to support sagging profits.

NEW CRITERIA FOR ANALYZING NEW TRENDS

A soft path approach to allocation of water asks the questions:

Who is going to require water?
How much of it is going to be required?
What quality of water is to be provided?
For what purpose will it be used?
And, most importantly, for how long will it be required?

Once these parameters are fully explored, we must tackle the additional problems created by both political and social issues. These more subjective factors are more difficult to quantify within any allocation process.

Not all uses require potable water; much could be drawn from recycle. Normal conservation measures could save considerably and, by eliminating such systems as the flush toilet, we will find that the average per capita consumption of household water is, in fact, quite low.

We need to undertake an inventory of the end-uses of water in all categories--agricultural, industrial, domestic, recreational.

Armed with this new data, building and plumbing codes should be revised. For example, most present building codes still design for 100 gallons/capita/day (gpcd). However, the national average stands at only 60 gpcd, thereby overdesigning by 40 percent.

BAN THE FLUSH

Given that agricultural and industrial users withdraw water from rivers and return it, albeit degraded, nearby, we can see that the impact of flush toilets on water consumption is massively disruptive. (Consumption technically meaning water not returned to its source.) Simply, flush toilets account for 40 to 50 percent of household water use. However we look at it, the flush system unnecessarily uses a significant percentage of the water in this country that is withdrawn and not returned to its source. Additionally, the system neglects the reuse value of human waste, converting it instead to polluting effluent. Senator Robert Stafford of Vermont has stated the problem well (McLelland, 1978):

> We are only now beginning to feel the increasing problems of water supply. The current water shortages in California, Florida, and other parts of the country are the first graphic indicators of a major national water resources problem. Current domestic water usage in the United States approximates 9.5 trillion gallons per year. Of that amount, 3.5 trillion gallons are used for the sole purpose of flushing toilets, with the average family of four using more than 50,000 gallons per year for that purpose...

> ...The conventional collection and treatment system which has been the single dominant concept for public sanitation in this country for more than 125 years is not an economically feasible solution for many parts of rural America...
>
> ...We must not forget...that there are still nearly sixty million Americans not provided with basic sanitation services... fundamental to the public health...the high cost of sanitation facilities in our rural areas is aggravated because we have attempted to use the same methods that have proven effective in the urban setting, and apply them to the very different problems of rural sanitation...
>
> ...In numerous cases, costs of $8,000 to $10,000 and even $12,000 per connection for conventional facilities have caused many communities to place heavy financial burdens on residents. Monthly service charges of $20 and $25 per month are not uncommon. Other communities have simply abandoned plans for public sanitation...It is estimated that there are between 15 and 20 million septic tanks handling the more rural unserved areas. A great many of these devices were installed in areas where they cannot function properly, and many areas have not been adequately maintained.

California State Architect Sim Vanderryn has speculated how future archaeologists might interpret the flush toilet system.

> By early in the 20th century, urban earthlings had devised a highly ingenious food production system whereby algae were cultivated in large centralized farmlands and piped directly into a ceramic food receptacle in each home.

Is this any more absurd than our practice of mixing one part of excreta with one hundred parts of precious clean water?

SPECIFIC INADEQUACIES OF THE FLUSH TOILET SYSTEM

The flush toilet system causes problems in the following areas:

- Pollution of the land needed for disposal of septage and sludge:
- Pollution of water used to transport the excreta
- Disruption of the natural water cycle through consumption of of large quantities of water not returned to source.
- Large direct and hidden costs in the designing, construction, maintenance of the elaborate toilet system, involving everything from pumping fresh water from the ground to monitoring the effluent from a sewage plant

- Large amounts of energy are required for construction, operation, and maintenance.

These are the major areas of impact, although there are ripple effects into many other areas, such as medical problems for those who drink contaminated water or alterations to marine ecology due to decreasing salinity and the introduction of toxic substances.

Costs of having a flush toilet include:

- The cost of buying and installing the toilet itself and the plumbing required within the house
- The cost of water and the installation and maintenance of an independent water pumping, treatment, and delivery system
- The cost of connecting to a sewer line or the installation and maintenance of a septic tank system
- Sewer use charges
- Waste treatment costs
- Costs incurred through final disposal of residual substances.

Considering only direct costs, the composting system compares favorably.

APPROPRIATE ALTERNATIVE FUTURES

The massive effort resulting from the Clean Water Act, the Safe Drinking Water Act, and the Resource Conservation and Recovery Act is basically a remedial program. What do we aim for afterwards?

When all communities have adopted appropriate wastewater treatment systems, conservation programs, decentralized management techniques, and appropriate technologies, what then?

All building codes and regulations must be revised to discourage the further mortgaging of our water and energy resources. We must further the development of passive building systems.

These are design principles which are quite similar to biological strategies found in natural living systems. Rather than seeking outside or additional energy sources, a building would rely on the design to "accept" the wealth of incoming solar energy and rainwater and manage it more efficiently so that supplemental sources are not required.

As the inflationary costs of meeting our basic needs of food, water, shelter, and warmth spiral higher and higher, it will be necessary to turn our attention to the design of greenhouse "bio-shelter" systems. Within these dwellings food could be grown continuously, regardless of the season; warmth provided naturally at no additional cost, and water and nutrients cycled appropriately, thereby eliminating pollution.

By integrating human waste and water recycling into such systems, we return nutrients and vital liquids to locally productive use. The use of greywater for aquaculture within the bioshelter itself offers far-reaching benefits.

Such opportunities for local ecosystem control of water pollution need to be thoroughly investigated. Every wrong step taken in handling water resources today, a step which might seem to be economically justified for the present situation, can result in significant future losses.

COMMUNITY PLANNING

Programs should be developed for building and construction which would, over a period of time, phase out water/energy intensive structures and replace them with water/energy recycling structures.

To achieve this, we need to evaluate and inventory buildings which are "consumers" and determine how long, at what cost, and what benefits would accrue by replacing them with appropriate buildings. It is folly to spend billions of dollars in a remedial program only to continue the pattern into the future.

In evaluating present and future research, it is important to look at the cost of upgrading water supply and wastewater treatment systems that are currently at the margin and that are also failing by virtue of age. It is also crucial to analyze whether it makes more sense to invest billions of dollars in renovation or to begin a steady investment of money into an alternative course on a soft path.

Assuming the average lifetime of centralized water supply and wastewater treatment systems is 40 to 50 years, then those plants built today will not need replacement until 2020 or 2030.

Rather than extend community dependence on centralized systems at greater and greater costs, we should be seeking a path that would allow for the eventual phase-out of those systems. A planned decentralization at the present time could complete about 50 percent of the phase-out process by about the year 2020.

OBSTACLES TO CHANGE

In the past, we have observed the tendency among engineers, State regulatory agencies, and others to continue to do things a certain way because that is the way things have always been done.

We recognize that often a multiplicity of approaches is the best solution. A tendency toward single-minded design (i.e., all septic tanks in a county) or a regional concept based on "economy of scale" costs the tax payers hundreds of millions of dollars and valuable land resources. The nagging tendency of people to continue to do things a certain way, regardless of whether there are new and more innovative approaches, prevents new concepts from being given adequate consideration.

Ultraconservatism is absolutely the most important reason why we have been unable to sell new, integrated regional concepts.

We continue to concern ourselves with the high cost of water disposal systems. These high costs are caused by inflation in construction costs since 1972. They are also caused by unworkable design guides used by State regulatory agencies.

Ultraconservatism on the part of consulting engineers is a major factor. Consulting engineers are content to use outmoded wastewater design concepts because their engineering fees are based on a percentage of construction costs and because Federal and State regulatory agencies virtually refuse to allow new ideas to be developed. New ideas upset the status quo and force professionals to revise their arbitrary engineering manuals.

This is not an implication that consulting engineers as a general group are irresponsible. However, with a schedule of fees, they find that it is hardly worth the cost and expense to oppose a staunchly entrenched bureaucracy to find new and better ways of doing the same thing. Engineers cannot afford to concern themselves too much with the most cost-effective design. They must work out a design acceptable to the State regulatory agency and to the local community so they can design the system and move to the next project. Neither do they concern themselves seriously with the community's repayment ability or ability to adequately operate and maintain the facility. Complacency and lack of foresight are to blame for the inability to move to more progressive, innovative ideas in the design of facilities (McLelland, 1978).

Similar attitudes among other professional groups within the existing water industry are equally predictable and understandable. The spokesman for such groups must represent the interest of his colleagues. They will hardly welcome innovations that appear to threaten their own livelihoods. Instead, they will argue to do the work they are trained for and paid for.

THE PROBLEMS WITH MANDATE

Another pressing problem has to do with translating policy into action at the State and local levels. Irrespective of the intent, mandate, or law at the Federal level, political and institutional obstacles can all but stymie any well-intended policies. As an example, after many years of effort, Title Five of the Massachusetts Environmental Code was amended, Article 17 approved, to allow the use of composting or dry toilets.

However, conflicting requirements of the Environmental Code, the plumbing regulations of the Massachusetts Building Code, and the Health Code remained. Consequently, those who wish to install and utilize a water-conserving toilet are still prohibited from doing so. Why? Because in that plumbing code, a "water closet" is still specifically cited as required in every dwelling before an occupancy permit can be issued.

Advocates of water-conserving compost toilets can expect another two or three years before the codes are altered. Opposing their opinion will be groups, such as plumbers' unions, who feel themselves threatened by the prospect of water conservation. Lobbying at the Federal level eliminated several provisions of the Clean Water Act amendments concerning direct water conservation requirements and penalties for noncompliance.

The crux of the matter does not lie in simply identifying programs and policies that can impart alternative methods and technologies for community water management. It also lies in what we must do to promote the concepts and market them effectively, so that they are taken up and become part of the American way of life.

In my experience, I find that the interest in water management is very high at an academic or philosophical level. However, economics spurs people to action. The cost of heating hot water, renovating sewage and waste treatment tanks, installing expensive wastewater treatment systems, rising costs in water and sewer billing--these are the issues that hold the public's attention.

The task is to demonstrate that water and energy conservation at the local level and in the individual home makes economic sense. A tax structure that would "dis-incentive-ize" central systems, encouraging the community and the taxpayer to decentralize, would be constructive here. The tax revolt may be a very timely development; it may encourage people to make the right connection at last between present archaic expectations and future financial good.

Even though Federal and State subsidies pay 85 to 95 percent of capital costs, the community still must pay for the continued operation and maintenance costs. In the eagerness to receive subsidies, long-term ramifications are all but forgotten. The relatively small share initially paid by the community masks the fact that its operation and maintenance costs will continue to be proportional to the total system.

CONCLUSION

The current crisis in water supply and wastewater treatment is the result of a "blind" population who, through centralized Federal and State management and financing methods, has had the true costs hidden from it.

The apparently inexhaustible water supply coupled with artificially low direct costs has fostered an incredibly high per capita consumption with subsequent requirements for more costly wastewater treatment.

In recent years, the true costs--financial, ecological, health, and welfare--have been revealed, and the facts are ludicrous. Billions of dollars are being spent annually for systems which are not doing the job and which are incurring greater costs than benefits.

While solutions have been sought on a national level, the problem has always remained a local issue. Today, more attention needs to be paid to the bio-geographical versus political and demographic aspects of water supply and wastewater management. No longer are central collection and treatment viewed as the optimum solution for wastewater management by the U.S. Environmental Protection Agency. With encouragement of many State programs, water conservation has now become a major factor in the main objectives of the Federal government.

"Dilution" is no longer the only "solution," as the large engineering firms have told us over the years. Now, there are viable alternatives which can solve many of the problems. However, mere awareness of the issues affecting the management of our water resources is not sufficient to effect the necessary changes. The tools enabling communities to implement appropriate alternative methods are as yet unfamiliar to the public. Therefore, research, educational and demonstrational components are needed.

The solution of the community water management problem is multi-faceted, requiring an integrated approach. Therefore, it must be examined in its entirety.

Management of such an endeavor becomes problematic at the level at which government and business traditionally respond. The benefit is achieved when the scale is both smaller and ecologically-based.

The program that we at ECOS have developed is based on the premise that local water conservation problems are best addressed by local community action. Federal or State interference in local affairs is always met with suspicion. Therefore, we organize local civic and social groups to work together with the local government in implementing their own programs. These groups distribute the hardware to the end-users. As a sales force "extraordinaire," the credibility of the program is maintained. Because the salesperson is a well-known member of the community from a trusted, community-oriented non-profit organization, resistance is more readily overcome.

ECOS provides detailed instruction and training as part of a comprehensive marketing support package. This is required to insure the success of the effort. A complete water and energy economics education program is provided with each water conservation kit. The end-user can now calculate the dollar benefits for himself.

The Federal commitment is to provide organization and support for local conferences which identify target communities and concerned citizens.

The State supports the research and educational program at the local level through community conservation commissions.

By harnessing the civic groups, local, State, and Federal resources, they can all pull together and can accomplish that which they cannot do alone: produce measurable results, not simply informed rhetoric such as this.

END NOTES

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Public Support for Water Conservation: The League Experience

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The League of Women Voters is a volunteer citizens group with 131,000 members organized into over 1,300 local Leagues in all fifty States, the Virgin Islands, Puerto Rico, and the District of Columbia. At the local, State and national levels the League is committed to promoting an open governmental system that is representative, accountable, and responsive to all citizens.

In 1956 the League undertook a comprehensive study of water resources in which our members across the country came to the conclusion that procedures should be established which provide information and an opportunity for citizen participation in policy decisions affecting the direction water resources will take. During the twenty intervening years this firm belief in citizen involvement in the decisionmaking process has been reaffirmed by our subsequent water quality, air, solid waste, land use, and energy studies. The League is thus committed to maximum public participation in governmental decisionmaking.

Our members at all levels of League--local, State and national--have both been responsible for and participated in public involvement and awareness projects and programs for many aspects of water resources planning and management, as well as in other natural resource areas. In the last three years the League of Women Voters Education Fund has had education and/or public participation projects in energy conservation, coastal zone management planning, safe drinking water, solid waste issues, and 208 water quality planning.

In these Education Fund projects we have focused on various aspects of education, awareness and on involving both the public and elected officials in planning and decisionmaking. These activities are distinct from our action, which is the developing of support for measures which meet the criteria in our positions which have been reached through member agreement. However, education and participation are also essential components for influencing decisions and legislation.

The League has found there are no hard-and-fast rules that will guarantee successful public participation. However, on the basis of the League's experience there are fundamental elements that must be included to lay the groundwork for a successful program.

The first element in a successful program is to explain the problem, and the need for planning or corrective measures, to the public in terms they can understand and that are relevant to their lives and self-interests.

Water conservation is similar to energy conservation in that changes in lifestyle patterns and personal attitudes must take place; citizens must be convinced that conservation is necessary. Some of the findings from our Energy Conservation Technology Education Program, which conducted pilot projects in four communities to demonstrate to the public how to use energy more efficiently in the home, are worth noting. The project locations were Tucson, Arizona; West Hartford, Connecticut; Northfield, Minnesota; and Wake County, North Carolina.

Based on information collected in participant surveys, public attitudes towards government and utilities in general were consistent at all four quite different geographical sites. While these attitudes were in response to energy conservation perceptions, it would appear that attitudes would be similar for water conservation. It was found that:

- Skepticism continues to pervade citizen reaction to government; i.e., there is an increasing distrust of politicians and government in general. Credibility is a serious and critical factor in trying to reach equitable solutions.
- Coupled with public skepticism and cynicism toward government is the rip-off syndrome. Many people feel victimized by high utility bills, insulation companies, etc.
- While it is often difficult to determine whether a citizen really has been taken advantage of, the point is that many people believe they are being ripped off, and that is the problem that needs to be dealt with.

It thus behooves both governmental units and water utilities to let the public know, from the beginning, why water conservation is important to them as individuals as well as for the general public good. Moreover, in some cases the public has either been burned or has perceived itself as burned by having higher utility bills after instituting energy conservation measures. Any water conservation program must ensure that conservation will pay off to the individual user and that he will not be penalized for conserving.

The second element is to keep the public informed from the beginning. The public must have a role in the determination of objectives and the way these objectives will be reached. Do not start by telling the public how things are going to be done.

In both our 208 projects and as League members active in designated or State 208 programs we have found that where the public has had a real voice in the determination of objectives and how they will be achieved, the end product has received public acceptance. But more importantly, there is also a commitment to implementation of the plan--architects are always enthusiastic about seeing their blueprints becoming a reality.

It is not at all unusual for technical experts to state that the public does not have the technical background to participate early on and that the public will be brought in when there is "something to react to." This is a sure strategy for creating public controversy rather than acceptance. Experts often have a narrow view which is broadened by the general expertise of the public and the result is not only a proposal that is accepted, but in many cases is one greatly improved by citizen input.

The third element is to explain frankly and honestly all of the alternatives that are available. Do not predetermine courses of action. If public support is desired, the public must have a voice in the decisionmaking process.

This is especially important when a change in rate structure is one of the alternatives in a water conservation program. Inflation, the Proposition 13 syndrome, and the rise in consumerism have made it difficult if not impossible for a public utility, such as sewer or water, to just "lay on" a new rate structure. In some cases our local Leagues have had to pick up the pieces when sewage treatment user charge proposals met heavy opposition because the public had neither been involved nor educated. For instance, in Pueblo, Colorado the League was able to defeat significant opposition and develop support for user charges through an aggressive campaign based on facts.

In our energy conservation projects it was found that there was public acceptance for easy-to-do conservation methods and there was also a strong emphasis on do-it-yourself projects. There is most likely the same prevalent attitude toward water conservation, and retrofit devices are relatively inexpensive and simple to install. The important factor, however, is that the public has had a voice in deciding that retrofit and other water conservation measures are an alternative that should be implemented.

The fourth element is to form an advisory committee from representatives of all the identified interest sectors. This includes not only obvious allies but those who are neutral or even antagonistic. It is also important to note that we have found in our 208 and coastal zone involvement that elected State and local public officials are also a public. In the last analysis they are responsible for programs and policies and should be participants in their development. Additionally, they can become very effective advocates for both a program and any needed legislative changes.

The advisory committee must not be a "Mickey Mouse" operation, technical experts must not "talk down" to citizens, and the committee must not feel "used." The advisory group should have a voice in the determination of objectives, alternatives to be considered, the selection of the alternatives to be implemented, and the choice of consultants if any are to be hired. It is also advisable not to separate a group into technical and citizens committees--this leads to citizen discontent and probable criticism of the final product. In an instance where a 208 advisory group was not divided, citizens not only became more technically proficient, but the experts were more responsive to the citizen or public viewpoint and the final plan tended to balance public and technical concerns.

I cannot emphasize enough how important it is to draw in all of the major interest sectors that will be affected by a water conservation proposal. All too often the "public" is represented by a League member, one representative from an environmental group, and one from the Chamber of Commerce. Remember the taxpayer organizations, the elderly and other fixed income persons, consumer groups and special interests such as homebuilders and plumbing suppliers. If you do not, they will surface later as the opposition.

The advisory group can become a forum for continuing discussion as a program is developed and also act as a link to the general public. In addition, if the program is acceptable, the group can be the basis for a coalition that will spearhead implementation. This is extremely important if an ordinance or legislation is an integral part of the proposal. A cautionary note: an advisory committee does not replace the public; there should be public information and meetings at every major decision point.

The fifth and last element is to keep an advisory committee after the proposed conservation program is completed. As I mentioned before, implementation will need public support. Be open to modification and reevaluation of plans as community conditions and public views change.

Thus far I have discussed the necessity for public involvement but not how to get the public interested enough to participate. While again there are no easy answers, we have found that successful public education and awareness programs are tailored to local conditions and concerns. In our Education Fund projects the more traditional public meetings and conferences have been utilized, but some innovative approaches have also be developed.

In our Coastal Zone Public Education Projects, Leagues in 28 coastal states, the Virgin Islands, and Puerto Rico developed programs to increase citizen understanding of coastal management plans. A number of these had very successful boat tours of coastal and harbor areas. One of these in Duluth, Minnesota attracted 170 persons in spite of rain and fog. The spin-off from such an "event" is the television and newspaper coverage that reaches thousands of local citizens.

In Hawaii the League sponsored a poster contest--open to students from kindergarten through high school--with prizes such as seaflight tours, air tours of the coastal zone, boat rides, and sports equipment. The posters illustrated "What Hawaii's Coastal Zone Means to Me." Not only were young students reached--which is also important for water conservation projects--but radio, TV and newspaper coverage was excellent. The Governor of Hawaii presented the grand prize awards which furnished further coverage.

Followup was provided by creating a traveling display of the winning posters for exhibition at shopping malls, schools, and public hearings throughout the State. It should also be noted that the major prizes were related to the reason for the contest, which kept the purpose in the public mind. A similar water conservation poster contest could offer related prizes.

The League's solid waste projects, which were located at ten sites across the country to foster interest and citizen involvement in solid waste issues, have also developed some innovative approaches. In Bloomington-Monroe County, Indiana a costumed "Tree" became a recycling spokesperson distributing posters at elementary schools. A "Drop of Water" could be just as effective! In Oregon there was a bus tour called the "Wasteland Express," and in Georgia a publication, Georgia Road Map to RCRA (Resource Conservation and Recovery Act of 1976).

In Waltham, Massachusetts the League distributed barrels designed for recycling and also held a "Wasteworks Trash Bash"--a flea market complete with bands, balloons, clowns, refreshments, and money for kids who turned in bottles and cans. There were also recycling exhibits. Again, the event was directly tied to the purpose of the project. A "Water Conservation Fair" could also develop public interest and awareness.

Piggy-backing an awareness of one area of conservation onto another is another approach. In our Tucson, Arizona Energy Conservation Project there was already an awareness of the need for water conservation and the project stressed water as well as energy conservation. In areas where this is reversed the energy savings of water conservation could be highlighted. The Tucson League used another approach that we have found to be very effective: they offered their programs to established groups rather than inviting them to meetings. Ninety-seven groups requested the programs, which were flexibly designed to serve the specific needs of each group.

In our Kansas 208 project the League took advantage of their State University's Telenet (a two-way television hookup) so that an interested person could go to a nearby location to take part in a meeting and question experts that were hundreds of miles away. While distance may not be as important in many areas, getting people to another meeting is often difficult. A meeting on the local educational or community television station where those at home can participate is a possible approach to developing both public interest and citizen participation.

We also learned in our 208 projects that small meetings or one-on-one consultations with local elected officials and community leaders can lay the groundwork for a new, little-understood program. We also found that cooperation among Federal, State, and local people was needed. In one State a person attending a 208 meeting remarked in surprise that it was the first time he had ever seen Federal, State and local officials on the same platform.

It is also important that the U.S. Environmental Protection Agency stay in close contact with State and local officials as it draws up water conservation rules or guidelines. The Federal Government is highly suspect and the more it convinces citizens and elected officials that its job is to help implement an extremely important program, the more successful it will be. Both citizens and local and State officials feel they must retain some control over their own lives.

In conclusion, the League has found that neither public participation nor awareness of the issues can be taked on to a program in a perfunctory way.

It cannot be an afterthought. A commitment to citizen involvement requires time and thought and often costs money as well. If people feel it is in their self-interest to do something, they will do it. So it is in the interest of any water conservation program to develop broad-based public understanding and support in order to achieve a proposal that can be implemented.

Wise Water Use—A Program for Children

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The availability of water has long been a determining factor in the development of major metropolitan areas throughout the United States and the world. Increasing demand for large quantities of water for municipal, industrial, and agricultural growth has made it necessary to consider water supply projects far advanced from those considered by our predecessors. In many parts of the United States, the water supply situation has become a critical issue or is expected to be a critical issue in the very near future.

Some of the areas that have had to address the issue of inadequate water supply are well known, such as central California, Denver. Colorado, and the Washington, D.C. area. Cities that are expected to have a critical water supply situation include Boston, New York, and Miami.

In northeastern Illinois, available water resources appear to meet projected water demands to the year 2010, according to an evaluation made by the State as a basis for allocation of Lake Michigan water to users. However, certain assumptions about supply and demand had to be made during the evaluation process. This process was necessary to meet the requirements of a 1967 U.S. Supreme Court decree, 388 U.S. 426 (1967), limiting Illinois to 3,200 cubic feet per second (cfs) of Lake Michigan water.

The assumptions were:

- increased water resources availability or utilization from a source other than Lake Michigan
- reduced water use as a result of major construction projects by the Metropolitan Sanitary District of Greater Chicago
- Population projections and expected industrial growth.

However, since it is difficult at this time to predict whether the population projections will hold true in the year 2010, the Department must continually review and evaluate the water demand situation with the possibility of reducing demand in mind. With water needs becoming a nationwide concern, Illinois must be farsighted in its planning to ensure an adequate water supply for the future.

After much deliberation, a strong water conservation program was determined to be the only effective way of reducing the demand on the available water supply. The water conservation program that was developed consists of three major components. The first component, systems management, is associated with short term reduction in use and demand that may not be applicable over the long term period. Systems management involves working with the communities on an individual basis to assure that the system's losses are not excessive, and that the system is generally metered so that it is possible to determine exactly where and how the water is being used. The reason for this program element is that the accountability of water used by different municipalities varies from 90 percent accounted for to a low value of approximately 52 percent accounted-for flow.

The second component of the water conservation program relates to industrial water use and reuse. This is an intermediate term program that will attempt to reduce demand from the industrial sector while at the same time assuring the industrial users that they will be able to continue their production at a cost which will not be prohibitive to them.

The third component of the water conservation program is the school education program, which is to be a long term project and is not expected to have immediate short term impacts. The main theme of the education program is creation of a general awareness of water and how we use it, how we misuse it, the source of local water supply, and where water goes after it has been used in the system. Two primary objectives of the program are to emphasize the point that water use is considerably greater than necessary, and to stress that conservation of a finite resource is essential.

The critical issue in the development of a curriculum program is, how does an agency such as the Illinois Department of Transportation initiate a program that will be effective and accomplish a desired end result? The first phase of the project was to bring together key individuals who were familiar with the program's objectives and the mechanism of curriculum development and dissemination to school systems. An initial planning session was held with staff from the Division of Water Resources, the Illinois Department of Local Government Affairs, Illinois Office of Education, and a professor from Northern Illinois University to discuss the development of the program. At that meeting, it was decided that independent writers with experience in development and implementation of curriculum programs and materials should be contracted with to write the curriculum materials. The Illinois Office of Education was responsible for compiling a list of such writers and the Division of Water Resources and Department of Local Government Affairs cosponsored a workshop to provide the necessary background information. Although the participants at the initial planning session were aware that a curriculum program may or may not be successful, they were in agreement that an attempt should be made.

Subsequent to the planning session, 13 writers were invited to attend a two-day workshop for briefing on the water conservation problem--what had been done to date and what the Division hoped to accomplish. The workshop was also attended by representatives from the Illinois Office of Education and Northern Illinois University. The first morning was spent discussing the issue of water use and misuse in a number of areas where a water conservation program might fit in with existing teaching outlines and teachers' guides. The afternoon session was devoted to generating ideas and outlining a reasonable program for the development of particular topics and study areas for the teachers' guides. On the second day, the writers attempted to put the project into better perspective. They each then selected an area of interest for development of a teachers' guide. Two major items were considered in making the assignments: 1) grade level of the materials to be prepared, and 2) topics to be covered, such as personal water use or leak detection within the home. Consideration was also given to such matters as a take-home activity sheet which would accompany the teachers' guides, and any experiments which might be appropriate.

The remainder of the workshop was spent discussing the various problems associated with the development of curriculum materials and more specifically, the dissemination of the final prodcut. The discussion brought out many problems of curriculum material dissemination which the state agencies were not aware of. The workshop participants agreed that during the writing of the teachers' guides and the subsequent review and modification period that considerable thought would be given to finding an effective method of distribution which would have some degree of assurance that the materials would be used.

By the end of the workshop, each of the 13 writers were given an assignment to write either one or two teaching guides. A draft of the teaching guides was to be submitted to the Department within 60 days. Once the materials were collected, they were evaluated by a committee of four, composed again of representatives from the Illinois Division of Water Resources, Illinois Department of Local Government Affairs, Illinois Office of Education, and Northern Illinois University. The review was to check the materials for format, review content, and to determine whether or not the particular study guide would fit into the sequence of a portfolio, or series of teaching guides. After the committee reviewed all of the materials they were returned with the committee's suggestions to the authors for further development.

When the Department received the revised materials, the Division of Water Resources staff developed a consistent format for the portfolio and prepared specific graphics to be included in each teaching guide or module.

To date, four teaching modules are relatively complete but still must be refined and reviewed, particularly with regard to the use of metric units versus English units.

The Department expects to have the first completed portfolio ready for presentation in the fall of 1979. Currently, various methods of dissemination are being evaluated. It was determined while developing the materials that a pilot program is essential to test the actual usefulness of the modules and to measure the success of the dissemination methods.

The pilot program will probably require personal contact with at least three school districts. Once the school districts have been chosen, an in-service presentation will be made at the individual school to explain the curriculum program as well as to select teachers to implement the program. The teachers selected for the pilot program should have a keen interest in the teaching of the water conservation program and also be willing to critique the materials. The Department will be strongly dependent upon feedback from the teachers for refinement of the modules prior to expanding distribution.

A summary of the curriculum development program for water conservation would be as follows: The Illinois Division of Water Resources has set a goal for the reduction of water use in northeastern Illinois. The reason for such a goal is to assure that all of the municipalities and industries in northeastern Illinois will have an adequate water supply to provide for the needs of the people for the long-term planning period. The projected reduction in water demand that might be accomplished by this program could be on the order of 10 percent. Although a 10 percent reduction may not sound like a significant amount, it would be possible to supply an additional 1.5 to 2.0 million people with the reduced demand. The objectives of the program are to promote wise water use by all the residents of northeastern Illinois. These objectives may take as long as 25 years to accomplish; however, the development of wise water use attitudes in school-aged children is more likely to produce a long-reaching reduced water demand.

Realistic data pertaining to the effectiveness of the program is expected to be available in two to three years. The Department will be continuously reevaluating the information it receives from the schools and the teachers in order to determine the effectiveness of the program and what modifications, if any, will be necessary.

A sample of the curriculum materials prepared by the Illinois Division of Water Resources is available on request from:

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Development of a Water Conservation Program in the Regional Municipality of Waterloo, Ontario, Canada

(Preface to Slide-Tape Shows by James E. Robinson)

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The Regional Municipality of Waterloo, formed in 1973, is the largest metropolitan area (pop. 300,000) in Canada still able to use ground water, which is cool and needs essentially no chlorination, as its sole source of water supply. In Ontario, regional municipalities were created by the provincial government to reform and strengthen county government over areas experiencing urban growth pressures. Because the supply system for a city was often located in adjoining rural townships, the responsibility for water supply was transferred from the local municipalities to the Regional Municipality of Waterloo at the inception of regional government, while the responsibility for water demand (distribution) and price structures remained with the local municipality. In response to increasing demand for water, the region has continued to drill more wells in rural areas. Recently, as a result of a perceived substantial lowering of water tables, the farm community has become adamant that no more wells should be drilled and that other supplies should be developed and used, especially when the cities do not take seriously stewardship of the resource. The alternatives considered were a large dam on the principal river in the area, with implications for social and economic disruption and flooding of good farmland, and a far more expensive pipeline to Lake Erie.

A group of eight university students were not satisfied that the only response in this situation was to increase supply. Althought the political structure's separation of the supply from the demand function mitigated against their views, they concluded that such actions as attempting to reduce demand and to change price structures, which neither level of government felt to be its responsibility, might be less costly financially as well as ecologically. The ideas they developed in their examination of residential, institutional, industrial, and municipal water conservation alternatives were sufficiently convincing that faculty members were able to gain financial support from various agencies in the three senior levels of government (Federal, provincial, and regional) to hire twenty students for the summer to further investigate conservation as an alternative. When the three city governments agreed to cooperate also, this project became unique in commanding support from four different levels of government. As well as doing further research on the viability of water conservation, these students also developed water conservation education programs including water bill stuffers, mall displays, slide-tape shows, etc. After some of this material was shown to the regional councilors, the latter extended their financial contribution for a followup nine-month project currently underway, which focuses on pilot testing of a residential water conservation program.

Economics and Water Conservation

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INTRODUCTION

Only recently has widespread support of water conservation developed. Prior to the early 1970's, most water suppliers and users were interested only in obtaining and using more water and not in water conservation. The averaging of high-cost new water supplies with low-cost water supplies (developed under inexpensive conditions) resulted in relatively plentiful supplies and low total water use charges. Recently, however, a number of reinforcing events have dramatically increased the cost of water, decreased the availability of water, and sparked widespread interest in water conservation:

- The passage of the Federal Water Pollution Control Act, which requires relatively expensive wastewater treatment
- The oil embargo and energy crises atmosphere, which increased awareness of conservation concepts to the point of vogue in some areas
- Weather conditions which reduced water supplies for a number of years in some heavily populated regions
- The very rapid escalation of costs of developing new water supplies, together with expensive potable water treatment requirements mandated by the Safe Drinking Water Act (SDWA)
- Alternative water resources use conflicts which have ranged from inter-regional confrontations for limited water supplies to widely published development-versus-preservation debates.

In the relative confusion and pressure for panaceas to mitigate the problems caused by these various events, many individuals have turned to the economics profession for speedy, efficient, and useable answers. Economists with their bag of tools and theories have responded. Unfortunately, many preferred solutions have not been widely implemented, not because they weren't economically efficient, but because of the difficulties of getting consumers and utility managers to accept the dicta that higher prices were the only answer. In most cases, however, marginal cost pricing is just one of a number of acceptable solutions available to achieve water conservation goals. In any case, if water conservation measures are to achieve general public acceptance, fairness as well as efficiency must be part of the solution.

To achieve efficiency as well as the public acceptance necessary for implementation, good, hard, detailed analysis of all of the factors comprising and tangential to specific water resources problems will have to be undertaken. Today's water problems are very complex, and feasible solutions will typically be obtained only through interdisciplinary approaches emphasizing water resources systems. Narrowly based engineering hardware or economic theory approaches have been and will continue to be rejected by water users. Basically this means that water conservation plans should include comparable data and analysis of consumers, their use patterns, the physical and social alternatives available or that can be developed to cause water use changes, and innovative financial options. It must be stressed that plans should address the whole water system: water supply and wastewater treatment are too interrelated for the water conservation plans and decisions of one not to affect the other.

This paper will briefly discuss four important factors of an economic but still interdisciplinary approach to water conservation:

1. Basic information needed for water resources systems analysis

2. Cost-effectiveness concepts

3. Pricing concepts

4. Water supply-wastewater treatment interface.

INFORMATION NEEDED FOR ANALYSIS

Why Conserve?

The first question that must be answered before embarking on a water conservation or flow reduction problem is, "Why conserve?" From an economic viewpoint, water conservation is warranted only when total costs--present, future, monetary, and environmental--exceed total benefits. This definition of when to conserve implies more reduced use than non-use. The statement also indicates the many factors that should be investigated to determine the desirability of whether or not to conserve.

Answering the "Why conserve?" question may help indicate where and how water conservation can be implemented. For example, the "Why conserve?" question could lead to additional questions like, "Is there a current water supply problem in obtaining new supplies, treating for potable use, and/or distribution?" And if so, are the problems high cost, environmental concerns, pressure maintenance, or other reasons? Asking the "Why conserve?"

question when flow reduction seems important could raise further questions associated with high wastewater treatment, receiving water assimilative capacity, plant efficiency concerns, economic growth and development concerns, and a myriad of environmental impacts.

In other words, conservation for only conservation's sake is not necessarily economically justified. Why? Because conservation usually entails giving something up--whether it be freedom of not being concerned with water use or, most often, some monetary cost and investment. In short, conservation is not completely free. It may be, however, the least cost alternative; and this is one point where economic analysis is applicable. To apply cost-effectiveness, however, demand and supply data are necessary in that they form the primary information base.

Water Demand

Assuming that there are sufficient indications that a water conservation program should be developed, information will be needed on the various types of demands for water supplies and wastewater treatment. By types of demand is meant the quantity and timing of water use and/or treatment requirements for specified purposes. Some typical demand disaggregations include residential, industrial, municipal, and commercial, as well as leakage and inflow-infiltration. Depending upon the specific situation, timing can include a range from hourly through seasonal, and for some situations, even decade variations relative to climatic cycles. Each of these categories may need to be further divided into subcategories such as Residential: household and outside uses; and Industrial: cooling, washing, and processing.

Further disaggregations may provide additional information that could indicate cost-effective conservation opportunities. For example, for industrial process, knowledge of both washing procedures and various pollutants could indicate recycling opportunities; for residential consumption, household use patterns might indicate which of several conservation methods would be most cost-effective.

Ideally, demand-use information should be developed on the basis of a historical framework (i.e., over time) and should include prices paid by users. Price information should include both water supply and wastewater treatment costs.

Within categories, demand-use information should be expressed in terms of common units such as "per capita," "per type of processing firm unit of output," and so forth. The degree of accuracy that these types of information should contain will vary with the situation. In some situations, relative magnitudes of differences may be sufficient. In other situations, it may be possible to use information from studies in other locations that approximate or otherwise fairly represent the study situation. For example, Figure 1 illustrates some typical residential water demands and a range of typical domestic demands by function. From general tables such as this it may be possible to make and use estimates for the study situation.

Indoor

normal range: 45-65 gal/capita/day

Outdoor (primarily lawn irrigation and auto washing)

Eastern U.S.: 10-100 gal/capita/day
Western U.S.: 100-200 gal/capita/day

Typical range of indoor residential water use by function

Function	gal/capita/day				Typical range of total use
	40	50	60	70	
Toilet	14-18	18-22	21-27	24-32	35-45%
Bathing	10-12	12-15	15-18	18-21	25-30%
Laundry	6-8	8-10	9-12	10-14	15-20%
Culinary and Miscellaneous	6-8	8-10	9-12	10-14	15-20%

Figure 1. Typical residential water demands.

In addition to use information, it is also advisable to obtain various socioeconomic information such as income, traditions, institutional constraints (e.g., building codes), education levels, and habits. Where possible, this information should be correlated with use patterns--even if only on an intuitive basis. Again, such information increases the possibilities of where and how conservation plans can be implemented. Table 1 illustrates some socioeconomic variables and typical effects that affect residential water demands.

Water Supply and Wastewater Treatment

Although it is often assumed that the physical facilities and their associated costs are well-known by utility managers, in many instances this is not the case. Frequently, physical facilities are constructed with allowances for growth (i.e., extra capacity) with the result that, over time, some portions of a supply or wastewater treatment system will be below capacity while other portions will be just at or over capacity. In these situations, total plant costs and total output may be known but the details or intricacies that are necessary for economic analysis are not available.

Furthermore, the engineering-physical and cost alternatives of system operation information needed for thorough analysis is frequently not available. This type of information is necessary to develop a base line scenario and economic, operational alternatives. It is from the base line that the analysis of conservation alternatives must be made.

In analyzing conservation alternatives, indirect effects may occur that affect the desirability of a conservation method. For example, a flow reduction program emphasizing reduced water quantities per toilet flush together with shower flow restrictors might trim peak hour demands sufficiently that supply-pressure problems during peak water use are alleviated.

The analysis of water conservation alternatives in an economic context also requires information on engineering design and costs associated with incremental increases in capacity. The cost per unit of new capacity should be compared with the cost per unit of savings due to conservation. Care must be taken to insure that costs and values relate to similar qualitative aspects. For example, assume that costs of a residential water conservation program are defined on the basis of quantity of delivered water saved. If these water conservation alternative costs are compared only to the costs of an alternative which develops new raw water sources, there will be an understatement of the new development alternative costs--the correct new supply development alternative cost must include not only costs of the new development but also treatment to potable standards, distribution, and treatment of the resultant wastewaters. As can be seen from the above examples, data requirements, as well as analytic capabilities, for comparative economic analysis of conservation alternatives can be quite substantial.

TABLE 1. RESIDENTIAL WATER DEMAND: TYPICAL SOCIOECONOMIC VARIABLES AND EFFECTS

Use	Variable	Effect
Indoor	Income	As per capita income increases, water use increases.
	Family size	As number of persons per residence or dwelling unit increases, per capita water use decreases.
	Age	Infants increase water use (laundry). Teenagers increase water use (bathing).
	Education and profession	Each causes variance to some degree (e.g., need for bathing, type of laundry - water or dry clean, etc.).
Outdoor	Prospect of rain	Regions with little summer rain irrigate more than those with more summer rain. Regions with intermittent droughts will irrigate at less than physically required.
	Area/dwelling unit	As irrigatable area/dwelling unit increases, water use decreases. Decrease is slight in the West, greater in the East.
	Income	As income increases, water use increases. Partially a function of lot size or area.

COST-EFFECTIVENESS CONCEPTS

Cost-Effectiveness Considerations

The primary effect of water conservation alternatives is to reduce the current demands for water supply and/or wastewater treatment. This demand reduction thus allows future or new demands to use current capacity instead of developing or building new capacity.

As previously stated, implementation of conservation alternatives usually entails some costs. Cost-effectiveness analysis provides a methodology that can both rank the efficiency of conservation alternatives, as well as indicate the most efficient alternative between conservation and new capacity.

There are four basic water conservation methods:

1. Educational
2. Proscriptive (legal)
3. Technical-physical
4. Economic pricing

In practice, the basic four methods are frequently used in combination to obtain reinforcing or synergistic effects.

Educational

Educational methods stress adoption of a conservation ethic by users. Education makes users aware of the idea that water is not a free good. In addition, educational programs can make users aware of technical methods that can reduce their water use. Educational methods generally are used with the other three conservation methods so that it is difficult to attribute the savings from the awareness aspect alone. However, there is some evidence to suggest that educational methods alone will reduce water demands by an average of two to five percent and a maximum of 10 percent. Educational programs are typically the most cost-effective of the four conservation methods--especially for small percentage reductions.

Proscriptive

Proscriptive methods include the use of enforceable laws and regulations which limit or otherwise restrict the quantity of water use. The use of laws and regulations in a water conservation program is usually very cost-effective--even when the costs of implementing and enforcing new regulations are considered.

There are many precedents for using proscriptive water conservation methods during drought conditions. Implemented regulations tend to vary with the local situation but generally limit lawn watering and excess runoff, require recycling, and require that various water conservation devices be used. Regulations do interfere with some personal freedoms, but in many aspects are similar to regulations governing use of other public services such as roads and highways. One study indicates a 10 to 15 percent water savings based on long-term use of regulations where drought conditions are frequent.

Proscriptive methods can be very effective to insure the use of flow reduction and other water conservation devices. For both new construction and retrofit installations, there are water conservation devices and techniques which can provide the same level of service as greater water-using devices. For both supply and wastewater treatment there is little loss of personal choice, a minimal cost, and substantial water conservation effectiveness. In these cases, proscriptive methods, such as changing building codes to require use of water conservation devices and/or techniques, are very cost-effective.

Technical-Physical

Technical devices and techniques to reduce water use include low-flow shower heads, water-saving toilets, various ways to reduce lawn irrigation consumption, and both industrial and residential water recycling and reuse. For new installations, these devices and techniques frequently are comparable in cost to more intensive water-using devices and techniques. Thus, they may be extremely cost-effective; i.e., there are water conservation savings at little or no additional cost. For those cases where water-conserving devices or techniques require additional capital or monetary costs, it is necessary to compare these costs to both the cost-effectiveness of other conservation methods and to the costs of new water supplies and/or additional wastewater treatment. A method for this type of analysis is presented later in this section.

Cost-effective total water supply and wastewater treatment savings for households can easily range from 20 to 30 percent. Depending on the situation, cost-effective use of water conservation devices and techniques in industrial applications has been documented with water saving as high as 90 percent of previous demands.

Economic Pricing

Increasing the price of water services is often a recommended method to meet water conservation objectives. There is no question that a rigorously implemented pricing policy will reduce water demands. By itself, pricing encourages the installation and use of water-saving devices and techniques. In essence, a raise in water prices forces awareness of water problems and requires users to either educate themselves or pay the consequences.

Pricing techniques are economically efficient in that they follow the normal market system in allocating scarce resources. As most utility managers have found out,however, they can be very unpopular with customers. Because of this unpopularity, pricing techniques have not been rigorously implemented in many areas. Educational programs that show the inequities and inefficiencies of a utility's present pricing or rate structure together with potential consumer monetary savings have helped to reduce the force of many antieconomic pricing arguments.

Pricing methods typically require the use of water meters and, thus, may entail substantial cost if meters are not already installed. Water demand reductions of up to 30 percent, however, have been documented when pricing structures have been changed from a flat rate (no meters) to an average rate (with meters). The installation of meters may thus obviate the need for substantial new plant capacity.

Water meters, however, are not always necessary for the effective use of pricing techniques. Even with flat rate customers, differential pricing can be used by raising rates for those water users that don't install water conservation devices or agree to various water use restrictions.

Cost-Effectiveness Analysis

Cost-effectiveness analysis compares the costs of achieving an objective by various methods. For water conservation, this amounts to determining the costs of achieving a percentage reduction in demand or quantifiable water savings. These demand reductions or water savings are in effect equivalent to an expansion of plant capacity. Costs to achieve an objective are compared both among conservation alternatives as well as between conservation and new capacity. It is extremely important that all costs as well as all savings be included in the calculations. It is at this time that the previously discussed data requirements are needed.

Present value analysis is used in cost-effectiveness analysis to compare alternatives to conservation that have both different costs and effective replacement lives. When the parameters for cost-effectiveness analysis are given, a table which illustrates break-even or cost-effective points can be developed. Table 2 is such a table and presents a number of fixed values that can be easily used for cost-effectiveness determinations.

The interest rates illustrated are averages of those typically faced by both consumers and utilities. The years are indicative of those often found with water-saving devices, probable effective lives of various programs, and replacement lives of supply-increasing investments. The water cost figures are probably low when all costs are considered but do indicate rates currently paid by consumers. The level of investments, \$10, \$25, and \$60, can be increased by any factor as long as the quantity saved/1,000 gallons/year figure in the body of the table is increased by the same factor. The calculations are based on the annuity principal which returns all of the investment plus interest on the investment in equal payments over the life of the investment.

The table indicates when it is cost-effective to make a given investment or under what conditions an investment is warranted. It is essentially a

TABLE 2. GALLONS OF WATER ANNUALLY SAVED BY DEVICE
IN ORDER TO JUSTIFY INVESTMENT

Interest rate and years	Water cost (per 1,000 gal.)	Investment		
		$10.00	$25.00	$60.00
		Gallons of water saved*		
6% 10 years	$1.00	1,359	3,397	8,152
	2.00	699	1,698	4,076
	3.00	453	1,132	2,717
6% 20 years	1.00	872	2,180	5,231
	2.00	436	1,090	2,616
	3.00	291	727	1,744
12% 10 years	1.00	1,770	4,425	10,619
	2.00	885	2,212	5,310
	3.00	590	1,475	3,540
12% 20 years	1.00	1,339	3,347	8,033
	2.00	669	1,673	4,016
	3.00	446	1,116	2,678

*Gallons of water saved are derived by the following formula:

$\{r(1+r)^n \mid (1+r)^n - 1 \mid^{-1} \{I\} \{C\}^{-1}$ = quantity of water saved in gallons

where r = interest rate; n = number of years; I = investment in dollars; C = cost of water.

table of break-even points that indicates when the value of water savings will just equal the costs--capital plus return on investment.

For example, assume a 10-year life and 12 percent interest rate. When will a $25 water conservation device investment be cost-effective? If consumer cost for water supply and wastewater treatment is $2/1,000 gallons, then a $25 investment must save at least 2,212 gallons/year of water to be cost-effective. Any device that saves more than the 2,212 gallons/year actually imparts a return greater than 12 percent on the investment. Given similar assumptions but a six percent interest rate, to be cost-effective only 1,698 gallons/year need be saved by the device. Notice that with this quantity of water savings the investment yield would be greater than most bank demand savings accounts.

The effects of interest rates and the dollar-cost/1,000 gallons on the savings break-even points can be readily seen from the table. These effects are important for comparing the break-even points for utilities versus consumers. For example, at a six percent per annum savings account rate, an investment of $10 and average $1/1,000 gallon cost to a residential consumer, a water conservation device must save 1,359 gallons/year for the consumer to break even; or if he has to borrow money at 12 percent interest, the device must save 1,770 gallons/year. The cost to a consumer, it should be realized, typically is comprised of both old and new costs; or in other words, the older, lower costs per 1,000 gallons, and the more recently incurred higher costs per 1,000 gallons.

The costs to a utility, on the other hand, of obtaining and/or treating additional water will usually be much higher than the average price they charge to consumers. If at the margin the cost to the utility is $3/1,000 gallons and the utility has a six percent borrowing cost, a device would only have to save 453 gallons of water/year to be cost-effective--less than half of that required for the consumer. In other words, there are instances when it will be cost-effective for a utility to install water conservation devices, whereas at the same time it would not be cost-effective for the consumer to install the same devices. This dichotomous situation arises, of course, due to the nature of average cost pricing and due to the lower borrowing rates typically encountered by public utilities.

There are a few points to remember when using this table. The first is that the total water costs should be used. For the consumer, this is the price he pays for water supply, for wastewater treatment, and any energy cost he supplies for water heating. There will be substantial differences in consumer costs between water used inside the house and that used for lawn watering and other outside uses and between heated and cold water. For water supply utilities, the cost figures to use are those of the value of delivered water. If water is lost through distribution leakage, the values should include not just that for which the lost water could be sold, but the incremental costs of obtaining new water supplies to replace that water which has been lost.

For wastewater treatment utilities, if water is gained through infiltration, the incremental costs of treating that additional wastewater should include all capital, operation, and maintenance costs. In regional growth situations, the reduction of inflow is comparable to obtaining new capacity. Thus, if a plant is at capacity and there is substantial infiltration or excess inflow (i.e., no conservation), the value or cost of the infiltration and excess inflows is equal to the cost of new plant capacity.

It should be recognized that cost-effective determinations can be used for expenditures other than devices. If an educational program is expected to decrease water use by three percent, the costs of the program per 1,000 gallons saved can be determined. Reference to Table 2 will then indicate if such a program is cost-effective compared to other methods.

There are a number of water conservation devices available for residential use. Table 3 lists some of these devices, their approximate cost, their approximate rate of water use, and the potential water savings of "regular" devices vis-à-vis water conservation devices.

By combining the information in Table 3 with typical data for water use per capita and percent used by function (Figure 1), it is possible to calculate potential water savings (Table 4). Except for the laundry savings (washing machine) a $10 conservation retrofit program would save over 3,000 gallons/person/year of water. (This assumes one person per residence; greater savings result at approximately the same cost with more persons per residence). From Table 2, it can be seen that such a program would be very cost-effective--even at water costs less than $1/1,000 gallons or interest rates greater than 12 percent per year. While it might not be cost-effective to purchase a new washing machine just for water conservation purposes, it definitely would be cost-effective for an original or replacement purchase (the cost effectiveness analysis would include cost of the washing machine, energy for hot water costs, water supply costs, wastewater treatment costs, interest rate, expected life of machine, and expected water savings).

The examples in Tables 3 and 4 encompass substantial variations. The values, however, span the normal range of water use, function, and savings. As such, they should fairly well indicate the potential water conservation savings and costs for most localities.

PRICING CONCEPTS

Elasticity

Pricing techniques for water conservation primarily rely on the basic premise that as the price of a commodity increases, the quantity of the commodity that is purchased decreases. The effect such a price change has on quantity is called demand elasticity. Knowledge of water demand elasticities for different uses of water is important to estimate the water savings effects of pricing policies or rate structures relative to conservation objectives. Water demand elasticities are also useful for estimating revenue changes under different rate structures. Most studies indicate that for a 10 percent increase in price, water demands will decrease less than 10 per-

TABLE 3. WATER CONSERVING DEVICES: COSTS AND RELATIVE SAVINGS

Device	Cost	Water use	Potential savings
Meter			
With flat rate to average cost pricing	$150-500 + O&M		20-30%
Toilet			
Regular	$60+	5-6 gal/flush	-----
Water saver	$60+	3-5 gal/flush	30-40%
Variable flush	$5-15	5-6 gal/flush 2.5-3 gal/flush	10-25%
Displacement			
Plastic bottles, Etc.	$0.50-$10	4.5-5.5 gal/flush	8-10%
"Dams"		3.5 gal/flush	30-40%
Shower heads			
Regular	$5-25	3-8(15) gpm	-----
Low flow	$5-25	2.3 gpm	30-75%
Inserts	$0.50-$1.50	2.3 gpm	
Washing Machines	$250-370 mean $300	38-53 gal/load (not cost dependent)	20% (a 10-gallon reduction)
Faucet			
Regular	$5-25	2-12 gpm	
Aerator	$1-5	3/4 gpm	≈50% min.
Spray tap	$5-25	1-2 gpm	
Irrigation			
Hand held	-----		≈50-90% (of plant need) no waste
Auto sprinkler	$70-150		20-50% of other watering or sprinkling
Drip irrigation	$30/120 ft^2		

TABLE 4. EXAMPLES OF DEVICE SAVINGS

Function	Assume % total use	Assume Savings	Water use (gpcd)			Water use (gpcd)		
			Without	With	Amount saved (annual)	Without	With	Amount saved (annual)
Toilets	40%	30%	18	12.6	5.4 (1971)	28	19.6	8.4 (3066)
Bathing (½ bath tub, ½ shower)	30%	0 30%	13	6.5 4.55 11.05	1.95 (712)	21	10.5 7.35 17.85	3.15 (1150)
Laundry	15%	20%	7	5.6	1.4 (511)	11	8.8	2.2 (803)
Culinary and miscellaneous (½ cooking, etc., ½ washing)	15%	0 50%	7	3.5 1.75 5.25	1.75 (639)	10	5.0 2.5 7.5	2.5 (912)
Totals	100%	23%	45	34.5	10.5 (3832)	70	53.75	16.25 (5931)

The above savings can be achieved for approximately $10.00 worth of devices.

cent, or in economic terminology water demands are generally "inelastic." For some cases, however, demands are "elastic;" that is, a 10 percent increase in price will decrease water demands by more than 10 percent.

For residential water uses, elasticities generally range between -0.1 and -0.5, with an average elasticity of -0.3. For individual portions of residential water uses, however, the elasticities may be quite different from the average. For example, typical lawn watering elasticities are between -0.5 and -1.2. These elasticity ranges, derived from a number of economic studies, are important indicators of the magnitude of price increases needed to meet conservation objectives through pricing techniques.

The use of demand elasticities to determine pricing effects can be made fairly easy with some simplifying assumptions. For instance, Table 5 indicates price increases needed to achieve water savings of 20. 25, and 30 percent, given a range of elasticities from -0.1 to -1.2 and given a range of current water prices from $0.40 to $1. Use of the table is relatively easy: for example, to obtain an approximate 20 percent reduction in water use with an assumed elasticity of -0.3 and a current water price of $0.60/1,000 gallons, the price of water would have to be raised by $0.40 to a total of $1/1,000 gallons. For another example, assume that a 25 percent reduction in water use for lawns is desired in the summer months. Assuming an elasticity of -1.2 for lawn watering and a current price for water of $0.60/1,000 gallons, a $0.12 increase will reduce by approximately 25 percent those summer demands due to lawn watering uses.

It is important to understand that for pricing policies to remain effective through time, the relative price of water must remain constant to other prices. In other words, to continue to achieve reduced use objectives, the price of water must continually increase by the rate of inflation.

It should be also recognized that socioeconomic factors such as incomes may affect demand elasticities. For example, as incomes increase, demand elasticities usually decrease. This means that greater price increases will be needed to achieve given conservation objectives in higher income areas. Finally, elasticities in the short run may be less responsive to price changes than in the longer run. This is due to the fact that it often takes time for water conservation devices to be installed, conservation techniques to be learned and, for habits to change.

Rate Structures

There are four basic types of rate structures (Figure 2).

a. Flat Rates--where a fixed amount is charged per time period regardless of quantity of water services used

b. Average or Uniform Rates--where a constant price per unit of water quantity is charged and is constant regardless of the quantity used

TABLE 5. PRICE INCREASE NEEDED TO ACHIEVE DESIRED RELATIVE SAVINGS GIVEN CURRENT PRICE AND ELASTICITY

Relative savings	Demand elasticity	Current water price $/1,000 gals.						
		0.40	0.50	0.60	0.70	0.80	0.90	1.00
20%	-.1	0.80	1.00	1.20	1.40	1.60	1.80	2.00
	-.3	0.27	0.33	0.40	0.47	0.53	0.60	0.40
	-.5	0.16	0.20	0.24	0.28	0.32	0.36	0.40
	-.7	0.11	0.14	0.17	0.20	0.23	0.26	0.29
	-1.2	0.07	0.08	0.10	0.12	0.13	0.15	0.17
25%	-.1	1.00	1.25	1.50	1.75	2.00	2.25	2.50
	-.3	0.33	0.42	0.50	0.58	0.67	0.75	0.83
	-.5	0.20	0.25	0.30	0.35	0.40	0.45	0.50
	-.7	0.14	0.18	0.21	0.25	0.29	0.32	0.36
	-1.2	0.08	0.10	0.12	0.15	0.17	0.19	0.21
30%	-.1	1.20	1.50	1.80	2.10	2.40	2.70	3.00
	-.3	0.40	0.50	0.60	0.70	0.80	0.90	1.00
	-.5	0.24	0.30	0.36	0.42	0.48	0.54	0.60
	-.7	0.17	0.21	0.26	0.30	0.34	0.39	0.43
	-1.2	0.10	0.12	0.15	0.18	0.20	0.22	0.25

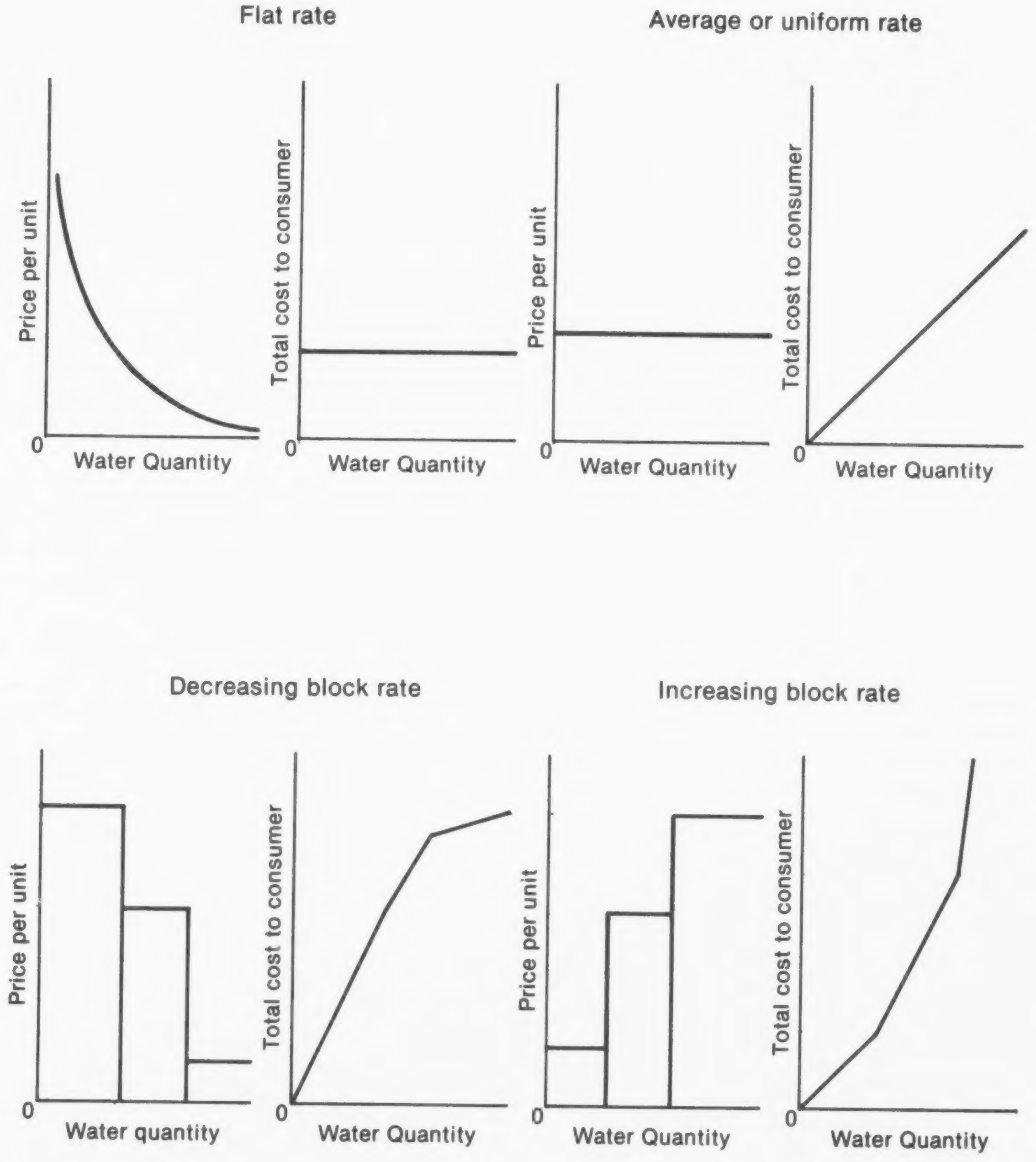

Figure 2. Pricing Techniques.

c. Decreasing Block Rates--where the price per unit of water quantity decreases as the quantity of use increases

d. Increasing Block Rates--where the price per unit of water quantity increases as the quantity of use increases.

Flat rates are generally calculated by dividing total operating and capital costs for a given time period by the number of customers. This amount is the supposed fair share of the cost for each customer. This method does not reward any individual customer who conserves water. The effective cost to any individual for using more water is essentially zero.

There are some common variations: higher flat rate charges for those customers that have larger inflow pipes and lower rate charges if a pressure or flow restriction device which effectively limits the quantity of water is placed in the entrance line.

Average rates are commonly used by many utilities. They do require the use of water meters and the consequent expense of meter readers. Average rates are commonly determined by dividing the total water quantity produced by a utility into the total operating and annual capital cost to supply that quantity. It rewards water conservation in that, if less water is used, the total bill is reduced.

In a situation where average costs are rising, the average or uniform rate is not necessarily equitable. This can be seen from Figure 3. Costs per unit are at the minimum at point Q_{MIN}. As more water is demanded, the average costs increase. With average cost pricing, the price per quantity charged must increase from P_{MIN} to P_{AC}. Those individuals, however, that conserve water may have to pay more per unit because of the large water use of others. In the extreme, the following example is possible: Suppose all but one customer conserves water so that total quantity for the system is just at Q_{MIN}. The exceptional customer uses so much water that average costs must be raised from P_{MIN} to P_{AC}. In this extreme case, all of the other customers are subsidizing one customer by the difference between the two rates.

In practice, if all customers use essentially the same quantity of water services, average rates will be relatively fair and will reward the individual that conserves. But, if there are large quantity differences among users, this type of rate structure is not fair.

Decreasing block rates encourage water use. This type of rate is based on the premise that water costs--water supply or wastewater treatment--decrease as more water is supplied and/or that it costs less to service large users of water services than small users. It is only through detailed cost analysis that the validity of either proposition can be determined. If total costs are actually decreasing (environmental costs included) then water conservation may not be necessary or even recommended. Where costs are increasing, this type of rate structure obviously subsidizes the large user at the expense of the small user. In some instances, this type of rate structure is used to encourage industry to locate in a region. The net effect of

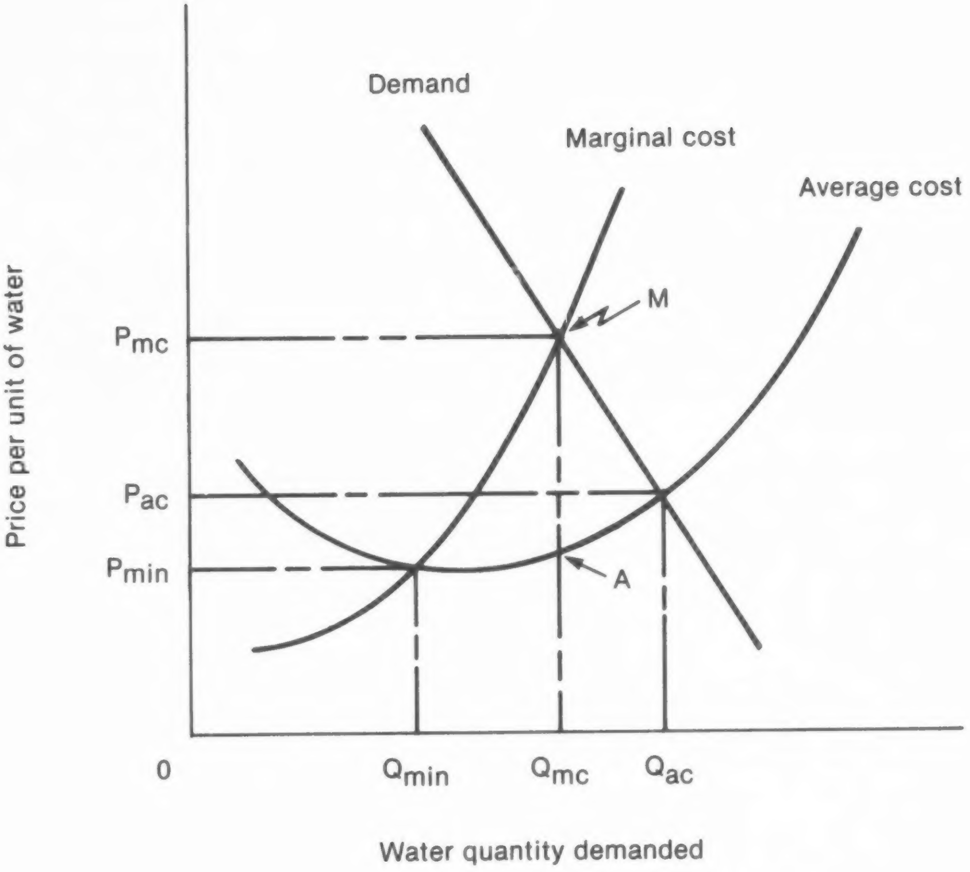

Figure 3. Average Cost Pricing vs. Marginal Cost Pricing.

such a policy is a water use subsidy for industry and a regressive tax on the community.

Increasing block rates are the most effective type of rates to achieve water conservation-flow reduction objectives. As larger quantities of water serviced are used, the consumer has to pay an ever-increasing amount for the last quantity used. Conversely, as smaller quantities are used, the consumer's total bill rapidly decreases.

Some common equity or fairness problems with increasing block rates are the adverse effect on customers who cannot readily reduce their water service use due to either large family size or due to undepreciated, expensive capital investments. The former problem can be alleviated by making special allowances for larger households (perhaps with annual or biannual verifications). The latter problem is more difficult to resolve, especially if investment or other action was taken with the explicit or implicit promise of low water costs for an indeterminate period of time.

Fairness problems eventually raise such basic questions as: (a) Are the major objectives of utilities to provide safe, potable water and environmentally sound wastewater treatment at the least cost for basic needs; or are the objectives broader to provide low cost service over and above basic standard of living needs? (b) Should prior residents who have "bought into" a water system early have to pay higher costs caused by demands of newer residents?

The concept that a utility should provide for basic needs first and at minimum cost provides a strong argument for increasing block rate structures. At minimum water service use, rate charges are often low. If everyone used minimum quantities, smaller systems or a reduction in size of new systems would occur. Total costs to the community would be reduced. It is realized that some efficiencies of scale might not be realized with smaller systems--the cost per unit of a one million gallon per day (mgp) plant is usually higher than the cost per unit of a 10 mgd plant. But the correct objective to minimize is not the cost per unit but the total cost to the community. Money not spent on water services can be used for better educational facilities or even an increase in retail business sales in the community.

Under an increasing block rate structure, minimal rates are imposed for basic water service. The effect of such a structure is that water services consumption competes directly with other retail goods and services. The increasing block rate is efficient in that it places utilities in competition for disposal income at the high water consumption levels but allows them to meet their public service, health, and safety functions at minimum cost to consumers.

The question of "buying into" a system early places the utility more in the framework of a cooperative with the early "shareholder" having a larger share than newcomers. This concept moves from the "public service to protect health and safety" mission under which most utilities have been chartered and thus become moot. For water service consumption in excess of basic needs, It may be possible to have differentiated, increasing block rates to accurately reflect costs of this additional service.

The practice of "hook-up" charges made for new service connections also deserves discussion. When these charges include a portion of plant capital costs, water service rates are necessarily not as large as if capital charges were included within the quantity charge. This concept can be seen in Figure 4, where the prepayment lowers average fixed charges and thus rates. Such prepaid charges, therefore, decrease incentives to conserve. They are also unfair since consumers who have "bought" capacity and then conserve de facto transfer their paid capacity to others.

Finally, where a strict, increasing block rate structure is used to encourage water conservation, revenues might exceed costs to the degree that "profits" might be excessive. In these situations, a rebate could be made to customers. If the rebate is timed properly--like just before Christmas--the income effect on water service will be nil, while the price effect reduces consumption throughout the year. Figure 3 illustrates how this plan could work. Assume that throughout the year customers were charged the marginal cost price, P_{MC}. They would purchase Q_{MC} quantity of water. This quantity is less than Q_{AC}, the quantity of water that would be purchased with an average cost rate structure price, P_{AC}. At Q_{MC}, however, revenues to the utility would exceed average per unit costs by the amount AM. This amount would thus indicate the size of a potential customer rebate.

WATER SUPPLY-WASTEWATER TREATMENT INTERFACE

The objectives of water supply utilities and wastewater treatment utilities are often diametrically opposed. The objective of many water supply utilities is simply to meet all demands for water use at the lowest possible price. Inexpensive, plentiful supplies of water are cited by these utilities as being necessary to encourage immigration and local economic development through new industrial and business expansion.

Besides local economic development objectives, however, in the past many water supply utilities experienced increasing economics of sale as they supplied more water. Given this experience, they were able to continually lower or at least hold constant in spite of inflation the per unit cost of water to their customers. These experiences have often led to a "more is better" syndrome which has been reinforced by local economic development, the expansive lawns of residential customers, verdant municipal parks and recreation areas, and the luxury of not having to be concerned with water costs or supplies.

For many water supply utilities, plentiful, low-cost water is still a reality. Two factors, however, have interrupted complacency for some utilities: the easiest, cheapest water supplies have been developed,and any

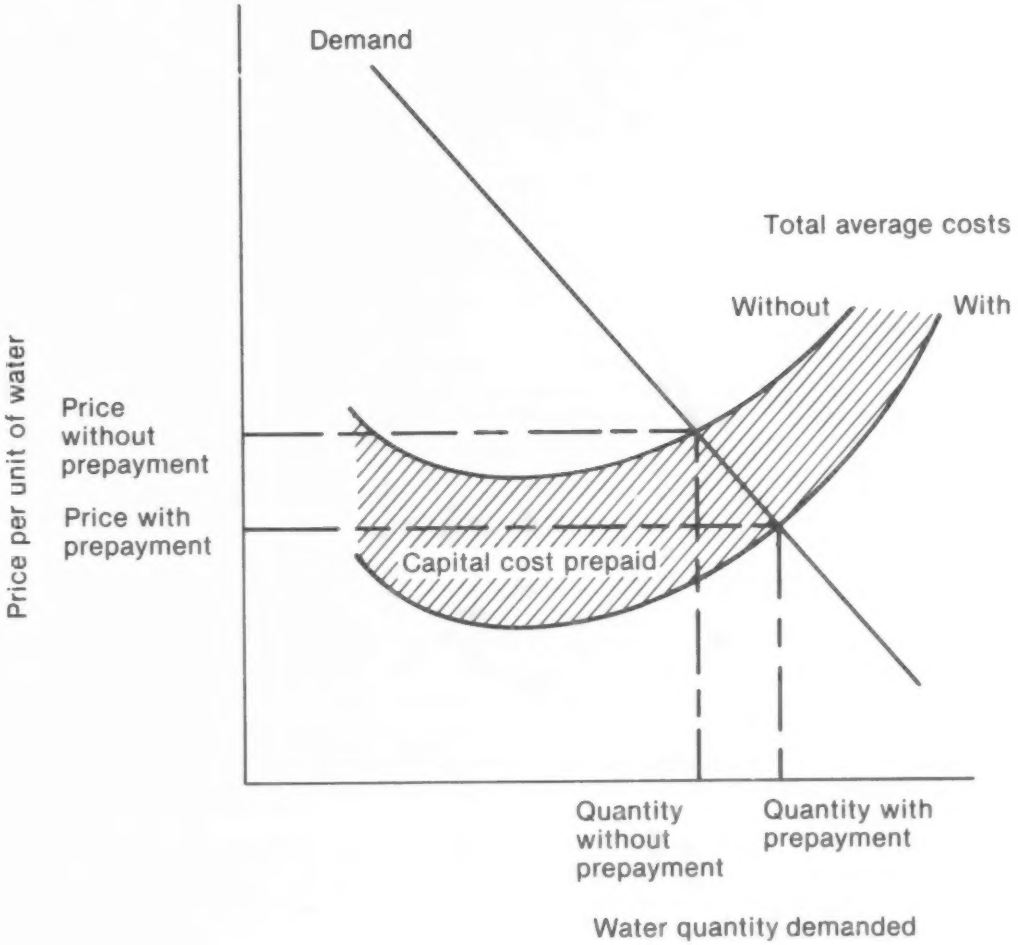

Figure 4. The Effect of Prepayments for Utility Service: Average Cost Pricing.

additional development will be relatively costly; and new potable water quality standards have increased treatment costs.

For the latter factor, the additional treatment for higher quality water will shift consumer costs upward on a per unit basis. Such an upward shift will undoubtedly be disquieting to large water users but will probably be only a one time increase.

Water supply increases due to new demands from population and/or business growth, on the other hand, are more likely to result in continually increasing incremental supply and treatment costs. There is a possible exception, however, to this conclusion, which is if new supplies come in very large increments. Once construction is completed, supplying water at the margin may not be too expensive. In fact, extensive water use may be encouraged to help spread construction costs over a large base and thus reduce the amount of unused capacity. Unfortunately, such rationalizations frequently are the cause for current problems and do little but to justify "more is better" arguments.

Wastewater treatment facilities with sophisticated treatment are expensive to construct and operate--often two to three times the cost of delivered potable water. There are sizable economies of scale in wastewater treatment plants. Frequently, offsetting these economies however, is the necessity to provide advanced treatment. This additional treatment becomes necessary because the total quantity of wastes remaining after secondary treatment exceeds the waste assimilative capacity of receiving waters.

If the quantity of wastewater can be reduced, even though waste concentrations increase, both construction and operation cost savings may result (efficiencies of waste removal may even occur). These potential cost savings resulting from reduced flows make water conservation a ubiquitous concern.

Given the above necessarily general and brief discourse on supply utility's and wastewater treatment utility's objectives, it is easy to understand why the objectives of these utilities may conflict: suppliers want and may need to sell more water to reduce unit costs; wastewater utilities need to avoid additional construction and desire to reduce operation costs. Water supply conservation may be encouraged during periodic, seasonal droughts where outside uses such as lawn watering consume large quantities, but conservation for domestic use may appear to be relatively insignificant or may tend to increase per unit costs (because of large fixed cost charges). On the other hand, outside water uses do not affect wastewater utilities, whereas their problems are primarily from domestic and industrial wastes.

Given typical utility financing problems, rate structures, normal water service demands, economies of scale, and the stereotyped objectives of supply and wastewater treatment utilities, it is of little wonder that water conservation goals for these utilities are frequently different and opposed. Mutual support of water conservation goals may not be financially wise--especially for the supply utility.

In the drive for low, per unit water costs, many utility managers forget that total water use costs to the community should be minimized--not necessarily the rate per unit of water. Public utility managers should be aware that their responsibility to their community is to keep total cost--supply and wastewater treatment--at a minimum. Table 6 illustrates potential community dollar savings or growth capacity made available through a rather simple conservation measure. Objectives such as potential economic development are best achieved through explicit measures and not inefficiently hidden in water budgets as de facto taxes.

Where separate water supply and wastewater utilities will not cooperate, it may be necessary for the community welfare to combine these two functions into one, cost-responsive agency. A less drastic measure, however, might be to institute different water use rate structures. Well-designed rate structures for both supply and wastewater treatment can reinforce water conservation objectives while still maintaining the necessary utility financial integrity.

Rate structures designed to be efficient, fair, conservation encouraging and sufficient revenue generators might appear complicated compared to either flat or uniform rate structures. Given the variety of structures in use by other public utilities (e.g., telephone, natural gas, and electric) designed to achieve similar objectives, there should be sufficient precedent and experience to allow water utilities to modernize their rates.

It is realized that each community has a number of special conditions that negate attempts to develop a ubiquitous example. A water conservation rate structure--whether for supply or wastewater treatment or both--will most likely contain increasing unit charges as quantity of the service or use increases. This feature rewards those who conserve and use less plant capacity and fully charges those who are responsible for high cost and capacity increments. Depending on local situations, rate structures may also include a constant, flat charge for service, seasonal differentials to either encourage or discourage use, rebate plans which encourage conservation but still avoid excess profits, or any number of other techniques--including proscriptive regulations.

CONCLUSION

Implementing water conservation programs requires data, analysis and skills different from those traditionally used in water supply and wastewater treatment agencies. The concepts of water conservation are frequently different from the concepts and objectives under which water utilities currently operate. Because of these different concepts and the information-skill base on which they have developed, the full advantages of water conservation programs are often occluded.

To realize the advantages of water conservation, it is necessary to thoroughly analyze both the supply-service system (water supply and wastewater treatment) as well as service demands. Only after systematic analysis is it possible to cost-effectively assess water conservation opportunities.

TABLE 6. POTENTIAL COMMUNITY SAVINGS FROM WATER CONSERVATION

Example: Assume

(1) A one-quart plastic bottle in toilet tank

(2) Four flushes/day/person

(3) Water cost: $0.50 supply + $0.50 wastewater treatment/1,000 gal.

	Savings	
	Gallons	Dollars
Per person		
Daily	1	$0.001
Annual	365	$0.365
Per 100,000 persons		
Daily	100,000	$100
Annual	36,500,000	$36,500
Per 500,000 persons		
Daily	500,000	$500
Annual	182,500,000	$182,500
Per 1,500,000 persons		
Daily	1,500,000	$1,500
Annual	547,500,000	$547,000

At total per capita demand of 100 gpd, a 1% increase in population could occur without additional water supply or wastewater treatment capacity investment by using this conservation technique.

There are four basic water conservation methods: educational, proscriptive, technical, and economic. Each method can be cost-effectively implemented singularly, but synergistic interactions are common which increase total effectiveness. Two water conservation methods that work especially well together are economic pricing and water conserving technical-physical devices. Efficient and equitable rate structures create awareness of water resource problems and encourage and make cost-effective water conservation devices. It should be realized that large price increases may be necessary to achieve conservation objectives if only economic pricing is used. Knowing the exact price-demand relationship is not always necessary--estimates are frequently sufficient. It should be emphasized that user prepayment of capital costs reduces per-unit water prices and thus tends to increase water use, while at the same time it is inequitable to those that conserve water.

Water supply and wastewater treatment utilities often have different managerial and financial objectives. Distinctions between total costs to consumers and cost-per-unit of water services must be considered if minimum, total-community-cost objectives are to be realized. Water conservation programs can be designed to achieve these objectives. Cooperation between utilities is necessary to meet these objectives. Utility cooperation in water conservation programs is necessary for efficient, fair rate structures that provide utility financial integrity.

Residential Water Conservation and Community Growth

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A reliable supply of water is essential for sustaining human habitation. Lack of a naturally occurring water supply or inability to import a supply has historically prohibited or limited urban settlement in the arid regions of the world. Despite truly remarkable feats of engineering in developing and transmitting water supplies to arid locations, the directness and certainty of the link between water supply and community growth is no less important today. A balance between water supply and water demand must be maintained, or a community cannot grow.

Until recently, the authorities charged with maintaining this balance have emphasized expanding the supply in response to growth-induced demand; little effort was made to modify demand. But increasing costs of new supplies, intractable water shortage crises, public resistance to developing supplies from the remaining surface water sources, and increased public sophistication regarding the relationship between water supply and community growth have led to increased interest in influencing water demand as a means of maintaining the balance. As rapid urbanization has come to be considered a negative factor in the preferred lifestyle and fiscal stability of many communities in the United States, local governments have begun seeking ways to control the community growth process within their jurisdictions.[1] Among the many strategies applied to this problem are the withholding of essential urban services, notably water and sewer, as a management strategy to restrain or direct community growth.[2]

Water conservation techniques are one of the chief means of reducing water demand within a community. This paper is concerned with the possible effects of water conservation on community growth potential and, in particular, with identifying the issues of public policy and management which link water use and land use in the urban context. The paper is addressed primarily to water conservation techniques in the residential land use sector. Most of the current literature and community experiences with water conservation techniques and community growth policies deal primarily with growth in the residential sector. To consider the potential implications of water conservation in industrial, agricultural, and energy production processes as

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well would significantly expand and complicate this paper. However, the relationships of all land uses to community growth and water demand are strongly interlinked and, thus, are all considered relevant in the context of specific issues.

The fundamental orientation of this paper is that water management policy is intricately connected with a multitude of factors affecting community growth. Further, the purpose of management policy is to regulate both water supply and demand through mediation of tradeoffs between costs of supply and conservation, effectiveness of various techniques, community development and land use options, and public attitudes. Individual household efforts for water conservation, the water consumption characteristics of individual development projects as determined by physical design, and the spatial distribution of land uses within a community as determined by a general plan or individual land use decisions are all considered, by virtue of their cumulative effect, to be directly related to water management policy.

This paper is organized in three major sections. It begins by briefly describing the general parameters of water supply and demand. The majority of the paper is then given over to discussion of the key issues relating to the management of water supply and community growth. This is followed by a brief description of the general approaches taken thus far to correlate the management of water and growth policy and an assessment of the effects of water conservation on these approaches.

It is concluded that water conservation can have significant impact on community growth. To the extent that water conservation practices alter the demand characteristics of a community, a given supply of water will serve more households and diminish whatever constraint to community growth may have been imposed by limitations of water supply. However, the maximum effectiveness of water conservation will depend on a level of sophistication and integration of policies planning and program implementation for community growth, land use, and water management, which is uncommon, if not unprecedented, in American planning experience.

PARAMETERS OF WATER AVAILABILITY

In the relationship of water availability to community growth, supply and demand are affected by four key factors and two subsidiary factors. For the purposes of this paper, these can be listed as the parameters, or determinants, of water availability. These parameters are:

- Location of the water supply in relation to the potential growth area.

- Time required to connect a growth area with the supply. This may be the lead time for planning, design, and construction of a major new dam or interbasin transfer aqueduct or a sequential time frame for extension of elements of the distribution system imposed by the local government.

- Public attitude with regard to current water consumption habits and the willingness to change them and with regard to the willingness to pay the cost of increasing the supply.

- Land use mix which determines the amount and quality of water required in a community. The potential significance of residential water conservation practices is, in part, a function of land use mix.

There are two other factors which are relevant to water availability but which are addressed in this paper primarily as functions of the four key parameters. Obviously, the quantity of water available is relevant, but in this discussion quantity is considered to be a function of location and public attitude. To the extent that the public is willing to import water from a distance, pay for recycling or desalinization, or any other means of enchancing supply, then the immediately available quantity of water is rendered less relevant. Much the same can be said of quality as a determinant of availability. Quality can be improved if the public is willing to pay or made less relevant if the public is willing to use lower quality water for lower priority uses.

Location and time are primarily factors relating to the supply of water. Land use is both a determinant of and determined by water demand. Public attitude affects both the supply of water (through public policy on new supply) and the demand for water (through consumption habits and land use policy).

MANAGEMENT AND POLICY ISSUES

The complex interrelationships inherent in water use and land use policies make it difficult to isolate specific issues. Virtually any question which is raised will have at least one aspect which suggests a number of further questions. However, certain subject areas do stand out. In this section, these subjects will be addressed as the focal point of issues in matters of water use and community growth policy.

One observation which may serve as a useful preface to the exposition of these issues is that many of them bring into a single policy framework the extreme poles of both public interest and potential for individual control. On the one hand, matters of community growth policy are often closely and strongly felt by the residents of a community, but growth is strongly influenced by factors well beyond the community's control. On the other hand, matters of water supply, particularly in regard to development of major new systems, will tend to be seen as more distant and not impinging on one's lifestyle. Yet the potential impact of individual actions on water management and policy decisions can be quite significant. The implication is that a sophisticated approach to community growth and water use, which integrates community attitudes with individual effort, can be highly beneficial. A lack of understanding of the issues invilved could result in contradictory and negative community policies and programs.

Significance of Water Conservation

The amount of water which could be made available for further community growth by conservation practices should be a major issue in formulating a water use policy. Conservation potential is determined by two key factors: public willingness to modify personal behavior or expend funds to achieve conservation and the water use characteristics and combination (or mix) of various land uses in the community. The potential effects of each of these factors and contributing variables are discussed in the following subsections.

Effects of Public Attitude on Water Demand

The attitude of the general public toward water use is a principal determinant of the relationship between supply and demand and, thus, the availability of water for community growth. Individual attitudes toward consumption habits and lifestyle preferences determine household demand for water. Public attitudes determine public policy regarding the creation of new supplies, quality, and allocation of competing uses. In addition, public attitudes determine land use policies which can affect both supply and demand.

In some cultures, people get by on as little as two to three gallons/day[3] for basic needs of drinking, cooking, and personal hygiene. The water consumption habits of people in industrialized nations often require a much greater volume of water per person to satisfy what we consider "basic needs." The total per capita consumption of water (for indoor and outdoor uses) can vary markedly between communities depending on a wide range of factors. Climatic differences often account for the greatest variations in water consumption. Consumption in the northern California coastal communities averages 153 gallons/capita/day (gpcd) compared to an average of 410 gpcd in the arid southeastern portion of the State.[4]

Among the other factors which affect water consumption are:[5]

- Density of dwelling units. Low density areas tend to have higher water demands for landscape irrigation. Low density also implies larger dwelling units with more people per household. Public preference for housing type determines density.

- Billing method. Water service billed on a fixed monthly rate disassociates for the consumer the amount of water used from the cost of water. There is no incentive to save. Metering the water service, on the other hand, provides a correlation between volume used and cost.[6]

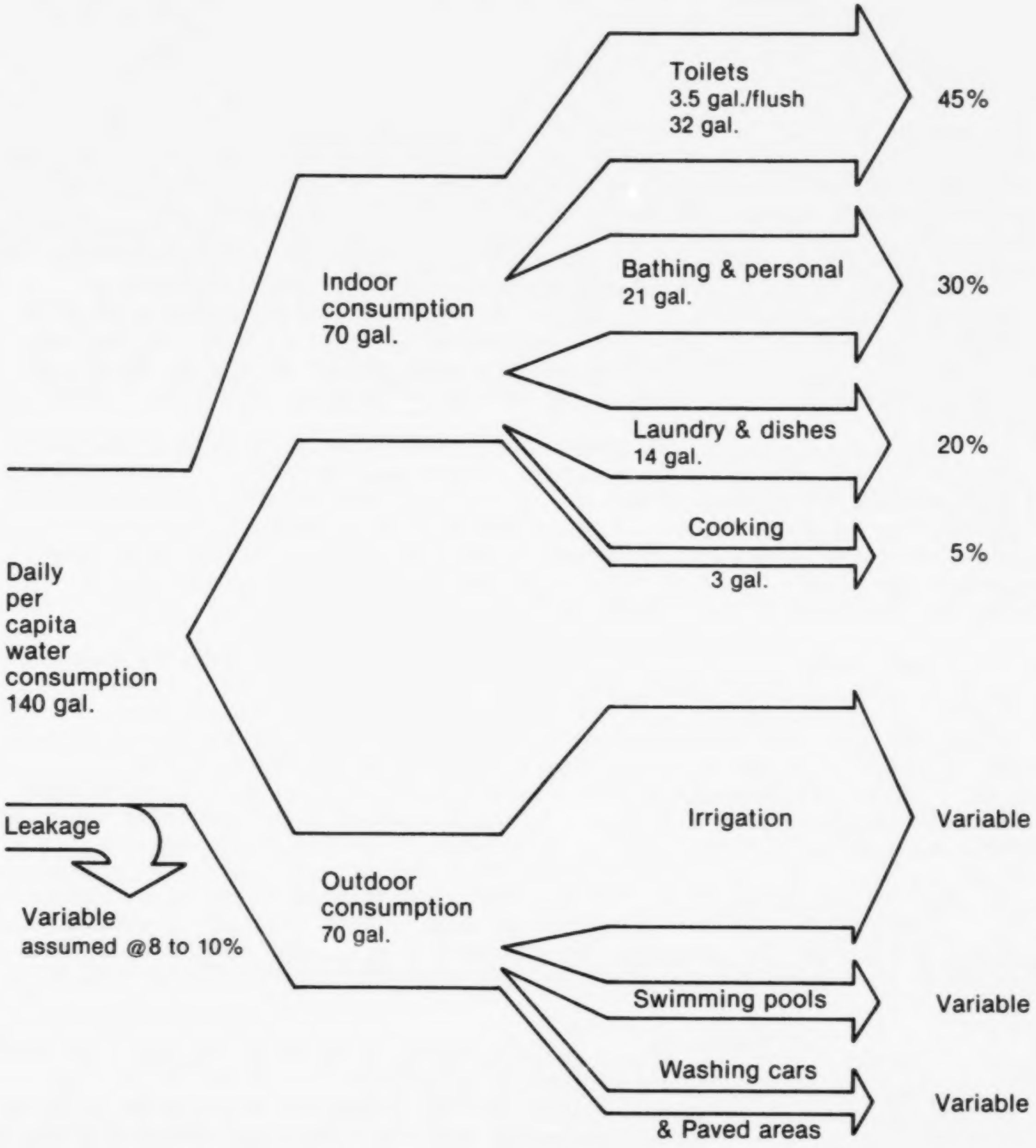
In addition, the use of public sewers results in heavier water consumption through heavier leakage and increased waste when taps are left running during intermittent use. Also, the age of a community can affect consumption because older, established landscaping may require less water than new plantings.

Even in areas markedly similar in the characteristics that affect water consumption, the water demand per capita can be significantly different. The community of Carmichael, a suburb of Sacramento, and the City of Novato, in northern Marin County, are similar in terms of population, age, income and education, land use mix and dwelling density, and climate.[7] Yet, average water consumption in Carmichael was 1400 gallons/service connection[8] compared to 950 gallons/service connection[9] in Novato during comparable periods prior to the 1976-77 drought. The power of public attitude to affect the rate of consumption was well-demonstrated in many locations during the drought. In the Carmichael area, average water demand dropped by 28 percent from 1400 gallons/service connection to 1007 gallons/service connection.[10]

Milne, in his study of residential water conservation,[11] divided residential water use into two categories: indoor use (drinking, laundry, bathing, toilets, etc.) and outdoor use (irrigation, car washing, pools, etc.). Typical consumption figures for both categories are somewhat arbitrary, but Milne selected 70 gpcd as an average indoor use and 70 gpcd as the average outdoor use. This total of 140 gallons/day of freshwater consumed by an individual is broken down as shown in Figure 1.

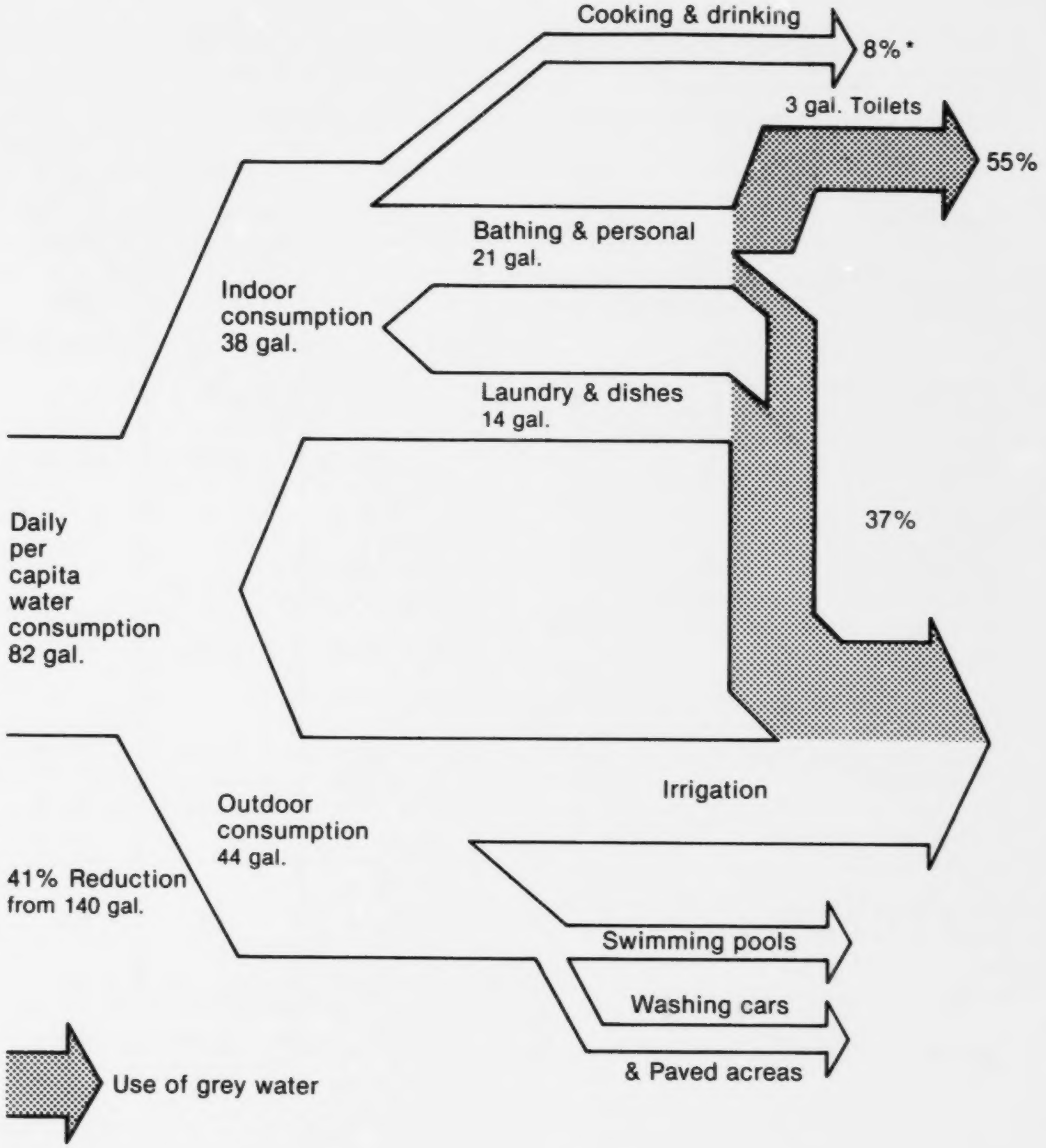
There are many devices and techniques available for reducing water requirements in the individual household. Milne has grouped many of them into functional strategies for implementing residential water conservation.[13] The strategies are organized according to immediacy of application, cost, and degree of sophistication. The most readily applied strategy, and the least costly, is simply attitude and behavioral changes on the part of individuals in their use of water. The essence of these changes is to limit use to actual need and avoidance of wasteful habits. While Milne did not attempt to quantify the cumulative effects of these attitudinal and behavioral changes, it should be noted that these are the very same techniques employed during the drought which yielded substantial savings in many cases.[14] A subsequent study by Milne of the potential for residential greywater use produced the estimate that household use could be reduced by 40 percent as indicated in Figure 2.

A study of possible water conservation measures in Los Angeles (Table 1) estimated that conservation could result in reductions as high as 23.9 percent in municipal water demand by the year 2000 compared to projects based on no conservation.15 The estimates assume that, by 1980, regulations will be in force for all new construction and replacements limiting flow rates for faucets and showerheads to 3.5 gpm, reduction of line pressures, installation of low-flush toilets, and water-conserving garden practices. In the absence of any conservation effort, population increases alone would push water consumption up by 10.3 percent, but the water conservation program actually reduces consumption from present levels by 23.9 percent, for a net change of 34.2 percent.[16]


Toilets
3.5 gal./flush
32 gal.
45%
Bathing & personal
21 gal.
30%
Indoor
consumption
70 gal.
Laundry & dishes
14 gal.
20%
Cooking
3 gal.
5%
Daily
per
capita
water
consumption
140 gal.
Leakage
Variable
assumed @8 to 10%
Irrigation
Variable
Outdoor
consumption
70 gal.
Swimming pools
Variable
Washing cars
& Paved areas
Variable

Source: Milne, 1976, Residential Water Conservation

Figure 1. Estimated Residential Consumption in The United States.


Cooking & drinking
8%*
3 gal. Toilets
55%
Bathing & personal
21 gal.
Indoor
consumption
38 gal.
Laundry & dishes
14 gal.
37%
Daily
per
capita
water
consumption
82 gal.
Irrigation
Outdoor
consumption
44 gal.
41% Reduction
from 140 gal.
Swimming pools
Washing cars
& Paved acreas
Use of grey water

* Indicates % of Freshwater consumed indoors

Source: Milne, 1978, Residential Water Recycling

Figure 2. Estimated Residential Consumption, Assuming Grey Water Use and Use of 1.5 Gal./Flush Toilets.

TABLE 1. REDUCTIONS IN WATER DEMAND DUE TO RESIDENTIAL CONSERVATION MEASURES

(PRELIMINARY ESTIMATES FOR A CITY THE SIZE OF LOS ANGELES)

	1980	1990	2000
Population	2,900,000	3,100,000	3,200,000
Projected demand (including industrial) assuming no water conservation, gpcd	183	183	183
Interior conservation (Low flow fixtures and appliances in new construction, rehabilitation, and maintenance repairs)	-3.3%	-9.7%	-16.4%
Exterior conservation (Increased irrigation efficiency, increased housing density, increased use of native plant materials, and reduction in system pressure)	-2.7%	-3.6%	-4.1%
Other non-residential conservation (Leak detection, industrial uses, commercial uses, etc.)	-2.2%	-3.3%	-3.4%
TOTAL	-8.2%	-16.9%	-23.9%
Revised projected municipal demand after water conservation, gpcd	168	153	139

Source: California Department of Water Resources, 1977, and Milne, 1978.

Effects of Land Use Characteristics on Water Demand

The mix of land uses, including the various ranges of residential development density, is a direct determinant of water demand. Land uses differ significantly in the amount of water required on a per-acre basis. Even substantially similar uses within a broad category often have differing water demand characteristics.

Determining the potential water demand for as yet undeveloped lands in urban land use categories is very uncertain due to the wide range of water-consumptive activities which could occupy a given location. Estimates of total water demand by land use category for large areas, as in Table 2, are not useful for estimating water consumption patterns for any given land use. They do indicate the relative magnitude of urban uses as a percent of total water demand.

Agricultural use is by far the largest consumptive use, with urban uses (including the categories "Self Supplied Industrial Uses" and "Public Supplies") accounting for only about 10 percent of total demand. Consumptive uses are those which are not immediately available for reuse without treatment.[19] If one considers all water withdrawn and delivered to initial point of use, the allocation of water to various use categories looks quite different, as indicated in Table 3.

Such figures for aggregate water demand by category have relevance to land use planning when they can be translated into some standard of common measurement, such as volume of water consumed/acre/year. Once such standards have been identified for the type of land uses likely to locate in a given community, and the potential for conservation is identified in each category, the plan for community development can be correlated to the availability of water.

The potential impact of residential water conservation on total water demand is a function of the percentage of total community acreage allocated to residential uses and the water consumption patterns of individual households. In California in 1972, individual homeowners on the average had direct control over approximately nine percent of the water used throughout the State.[21] In the South Coastal region, however, which includes highly urbanized Los Angeles and San Diego, the urban water use accounted for 71.3 percent of the total water demand.[22] This percentage represents a regional requirement of 2116 mgd of water, which is 46 percent of water required for all urban users in the State.[23]

An example of the potential for water conservation in new residential development comes from the North Marin County Water District. Since the early 1970's, the district has maintained records of water consumption by residential land use categories. Because all service connections are metered, they were able to gather rather precise data on not only residential use, but other uses as well. Based on this empirical data, the District formulated a standard unit of average daily water demand/residential service connection. This was termed an "equivalent unit" and represents an average daily demand of 950 gallons.[24]

TABLE 2. ESTIMATED CONSUMPTIVE FRESH WATER USE IN THE U.S. BY CATEGORY, 1975

Water use category	Volume consumed (mgd)	Percent of total consumed
Public supplies	6,700	5.6
Rural use	3,400	2.9
Irrigation (including conveyance losses)	103,000	86.4
Self-supplied industrial users	6,100	5.1
Total freshwater consumed	119,200	100.0

Adapted from Murray, et al, 1975.

TABLE 3. ESTIMATED WATER USE IN THE U.S. BY CATEGORY, 1975

Water use category	Volume withdrawn (mgd)	Percent of total withdrawn
Public supplies (including domestic, commercial, and industrial uses)	29,000	8.4
Rural use (including domestic and livestock use)	4,900	1.4
Irrigation	140,000	40.7
Self-supplied industrial uses (including thermoelectric power use)	170,000	49.4
Total water withdrawn	343,900	100.0

Adapted from Murray, et al, 1975.

Again, using empirical data, the District has assigned a ratio of the equivalent unit to each of the three dwelling types which are the dominant land use in the urbanized portion of the District. They are as follows:

• Single family detached dwellings	1.05 equivalent units [25]
• Apartments	0.45 equivalent unit
• Condominiums	0.70 equivalent unit

By measuring the remaining allocatable water in the District's supply sources in terms of equivalent units and by monitoring the number of equivalent units represented in each residential project approved by the local planning authority, the District can keep an accurate estimate of its remaining supply. These figures for equivalent units are an established management tool for the District and have been quite useful during periods of shortage.

Prior to the drought, but at a time when the remaining supply was very near the net safe yield of the District's primary supply reservoir, the District and the local government received a proposal for a residential development of 1400 to 1700 dwelling units.[26] Even the water demand for the first phase of this project far exceeded the remaining supply. In order to meet the demand for the first phase, the District formulated a set of conservation measures designed to reduce water demand such that the required number of equivalent units could be reduced by approximately 50 percent. The project developer, faced with having only enough water for a first phase too small to be economically feasible, chose to reduce the demand by including the District conservation proposal in his project design. The following conservation measures were used in that project.

- All interior plumbing in new buildings shall meet the following requirements:

  a) Toilets shall not use more than 3.5 gallons/flush except that toilets and urinals with flush valves may be installed

  b) Showerheads shall contain flow control inserts, valves, devices, or orifices that restrict flow to a maximum of approximately 3.0 gpm,

  c) Kitchen and lavatory faucets shall have aerators or laminar flow devices together with flow control inserts, valves, devices, or orifices that restrict flow to a maximum of approximately 2.0 gpm.

- All new parks, median strips, landscaped public areas, and landscaped areas surrounding condominiums, townhouses, apartments, and industrial parks shall have a well-balanced automatic irrigation system designed by a landscape architect or other competent person and shall be operated by electric time controller stations set for early morning irrigation. Landscaping covering clayey

> soils and slope areas shall be equipped with low output sprinkler heads permitting a slow water application rate. Prior to installing the irrigation system, the landscaped area shall be scarified and covered with a mixture of not less than four to six inches of topsoil (preferably native topsoil) amended with at least four cubic yards of organic material (nitrolized redwood sawdust, rice hulls, or equivalent/1,000 square feet and other soil amendments in a quantity and type approved by the developer's landscape architect. The District Board of Directors may, on the written request of an applicant, waive any part or all of the requirements of this subsection if it finds that the area to be landscaped is too small or does not otherwise justify the automatic irrigation system or soil preparation.[27]

Such measures are now recommended for all new residential projects. The ratio of equivalent unit for each residential category is reduced if the developer agrees to include these measures in the project design. As a result of reducing the raios, the water needed for allocation to the project is assumed to be reduced, and the District's fee for extending new service is reduced proportionally. The ratios are reduced as follows:[28]

• Single family detached dwellings	13 percent
• Apartments	30 percent
• Condominiums	30 percent

When conservation techniques and devices are incorporated in the physical design of new development, public acceptance of water conservation strategies is considerably enhanced. The amendment of normal approaches to new project development through site planning, selection of plant materials, dwelling unit design, and specification of water conserving devices allows the project resident to contribute to the community's water conservation efforts with little cost or effort on his part. Reduction of water consumption is simply the extension of a new lifestyle in a new home. Public attitude toward water conservation is gauged, in part, by the market acceptance of projects which feature conservation measures as an integral element of the design.

Effect of Conservation on Land Use

Just as land use policy can significantly affect water demand, water conservation can affect land use patterns. Water conservation extends the water supply and thus allows additional growth, but conservation also has the potential to affect the spatial distribution of new growth.[29]

One possible impact of water conservation is that the efficiency and thus, the viability of onsite, single dwelling water and sewer systems may be improved. These systems, typically consisting of an onsite well, septic tank, and disposal leach field, require a certain minimum land area to function safely and efficiently.[30] In many communities the relatively low density, which is characteristic of this type of residential activity, is the preferred lifestyle. Increased demand for water quality enhancement and projection and the apparent failure of individual systems to achieve these objectives have resulted in many instances of requiring new sewer systems for entire communities.[31] The sewering of a community allows for significantly smaller lot sizes and, consequently, often results in considerable subdivision and development activity. The community growth which follows often strongly conflicts with the lifestyles of the original residents.

More efficient use of the onsite systems through reduced flow to disposal leach fields would produce fewer failures in individual systems. The minimum lot size necessary to support these systems might be reduced to a certain degree, depending on local conditions, but, on the whole, the low-density residential pattern could persist. Such a development pattern might therefore provide a more permanent boundary for the urbanized core areas by resisting the current tendency to extend into unurbanized areas in piecemeal and erratic fashion.

A second possible effect would occur in areas already served by public sanitary sewer systems. In many instances, the sewage treatement provided by these systems cannot meet the objectives of the Federal Water Pollution Control Act of 1972.[32] The response to this situation in many metropolitan areas has been to abandon these smaller systems in favor of one centralized regional treatment facility linked to the existing systems by massive collector networks.[33] This centralizing tendency has two major implications for community growth:

- The development pattern for all regional growth will tend to locate on or near the main collectors to minimize connection costs. This will work to obviate whatever distinctive, community-based development pattern might have existed as a reflection of the scattered smaller sewage collection and treatment systems.
- The centralized facility, unless developed in incremental phases, will be sized to accommodate all the projected growth for the combined service areas of all the smaller systems it will replace. Consequently, at the time the central facility is completed, any phased growth strategy based on the capacity of smaller, decentralized facilities is immediately rescinded by the capacity of the larger system. Capacity of the local treatment facility will no longer be a tool for the local planning authority to regulate community growth. Growth management at the community level could still be achieved by withholding the extension of sewer service into as yet unserved areas, but plant capacity would be a moot issue.

Water conservation could provide an alternative to aggregating small treatment facilities into a single, centralized, regional-scale facility. Conservation would reduce flow to the treatment facilities and could allow some of the small facilities to remain in service longer.[34] Funds that would be spent on completely new facilities might then be better spent on upgrading existing faciliites to meet water quality standards. The benefits of this approach include possible savings in capital outlay; community growth would remain more direcly under the control of local residents; and communitiew would be more likely to remain physically distinct.

Reduced flow in sewage pipes might also allow the existing collector system to serve a higher density or a more diverse mix of uses in already developed areas. New pipes to serve developing areas might be sized somewhat smaller, thereby reducing the front end costs of new land development.[35] The effect of water conservation in domestic use is not likely to affect the minimum size of pipes for water delivery to most land use categories because these are typically determined by fire protection requirements rather than water consumption.[36]

Time Frame for New Supply Projects

The time frame for developing new water supplies, from the point when the decision is made to proceed to the point when the new supply comes "on-line," can be several years--up to 12 to 15 years for some projects. Planning for these new projects must rely on projections for future water demand which are often highly speculative, and, as indicated above, even projections based on very good population data can become greatly distorted by changing consumption patterns.

In this area of uncertainty, any flexibility in the time frame for planning and developing a new project can be very beneficial. Water conservation practices can extend the available water supply and relieve pressure to proceed with a new project which is uncertain in terms of ultimate need, appropriate timing or funding, or possible alternatives to the project. The flexibility afforded by water conservation could conceivably have the following benefits:

- It might allow the sponsoring agency to forego stopgap measures for providing an interim water supply in times of crises when a major new facility is in the planning or development stage.[37] Such interim measures are often quite costly in terms of their relative utility and are often dismantled or abandoned as obsolete when the new facility comes on-line.

- It may allow the sponsoring agency to choose when it wishes to enter the bond market for funding of a new project. The savings in debt service expenditures over the life of a bond can be quite significant with a fractional fluctuation in bond interest rates for a large project.

- It may allow the sponsoring agency to wait for alternative project proposals involving other agencies or improved technologies.

Water Rights/Allocation to Competing Uses

We are concerned in this paper primarily with growth in the residential sector, but clearly the use of water for one sector must be considered in relation to competing demands from other sectors. A recent study by the University of California on major issues facing agriculture indicates that water will be the most important of all resource questions in the 1980's and beyond.[38] As demand increases, the competition for readily available supplies will become quite forceful. The key issues will be renewed pressures to develop new supplies at public expense and, more relevant to this paper, conflict over reallocation of present water rights and the potential for conservation in the competing sectors.

The potential for conservation in any given sector will be viewed optimistically by water users in competing sectors. They will see reduction of demand in one sector as additional supply which can be made available to another sector. But this attitude among competing users overlooks two key factors. First, there are costs inherent in most conservation programs which must be borne by the consumer. Second, the water conserved might best be used by additional growth in the same sector rather than reallocation to another purpose. The allocation of water to competing uses must be based on realistic water demand estimates for the various uses, including the feasibility and magnitude of conservation potential in each and the amount of land area allocated to each use in a rationally-derived general plan.

Under current water rights law, the practice of water conservation techniques can have a negative effect on future allocations should the present allocation be subject to review.[39] Although the application of water rights law varies from State to State, and even basin to basin, the most common doctrine in the Western States is that of "appropriation".[40] The doctrine's basic tenets are that a water right can be acquired only by diversion of the water from the watercourse, or aquifer, and its application to beneficial use.[41] An earlier acquired right shall have priority over others wishing to appropriate at a later time.[42] Furthermore, an appropriation right is independent of the location of the user's land to the water diverted, and the right can be maintained only by use.

In essence, then, a water right is based on the ability to put the water to beneficial use on a continuing basis. Any sector which anticipated a significant degree of growth would try to establish and maintain a large enough claim to accommodate the new growth. But conservation practices would ostensibly reduce demand and, thus, the justification for the current water rights allocation. When the allocation is subject to review, either as a provision of the initial allocation or under pressure from competing users, the allocation may be reduced in relation to what may be perceived as inability to use the available supply. Although such a determination may be quite reasonable, it is not likely to be so perceived by advocates for the community's growth potential.

The present system of allocating water to competing users is not conducive to implementing water conservaton in sectors which see continued growth as necessary to their continued well-being. It is not conducive precisely because the various sectors are viewed as being competitors for a limited resource. Water rights become the battleground for determining whose interests shall survive. The true determinants of which uses should expand and which stabilize or contract are much broader than the availability of a single resource. What is required is integrated land use and economic and resources planning for community growth.

Water Quality

We have been accustomed in this country to expecting a single, rather high standard of water quality for virtually all domestic uses. All water used in a household is expected to be of potable quality, even though the ultimate use of a portion of that water may be no more significant than flushing away a spent facial tissue. But not all uses require the same level of water quality, nor is quality measured the same way for all uses. For example, water with nitrate levels high enough to cause public health concerns if used for drinking can be used beneficially by most crops. Municipal uses for drinking and bathing need higher quality standards than for washing cars or flushing toilets; industrial uses for food processing need higher quality standards than for power plant cooling.[43]

Acceptance and application of the principal of different standards of water for different uses can make a major contribution to extending the water supply. Water can be used again and again as a means of reducing demand on freshwater supplies. By conserving the supply of freshwater for priority uses which demand high quality, the potential for further community growth is enhanced.

The use of reclaimed water for low priority use, such as for irrigation or industrial process cooling, has been extensively studied and applied in a number of cases.[44] Reclaimed wastewater, however, has relatively little potential for significantly affecting total community water demand. Extensive use of reclaimed wastewater is hampered by public resistance to direct use of reclaimed water for domestic supplies[45] (although it has been used for direct contact water recreation facilities[46]) and by the cost of distribution facilities for the reclaimed water. Collection of wastewater at point of use, transportation to a centralized treatment facility, and redistribution to the point of use would require duplication of a very expensive infrastructure.

The greatest objection to use of reclaimed water for secondary use is that it represents such a tremendous waste of resource. Water which has a very light pollutant load (such as most domestic greywater) and which would be highly suitable for secondary uses is automatically batched with highly polluted wastewater (such as human waste). The entire batch is immediately reduced in quality to the lowest common denominator such that extensive treatment is required before any of it can be used again. The potential for secondary use of lightly polluted water sources is irrevocably lost by degradation in batching with lower quality water.

A much more suitable approach to utilization of non-freshwater sources is sequential application in uses with descending quality requirements, or as Milne has called it, the "cascade" approach to water use.[47] The concept simply suggests that water can be passed from one level of water quality requirement sequentially down through lower levels of water quality need until it has no further feasible application and can be sent on for treatment to begin a new cycle. In a single household, this process might involve use of a single volume of water two or three times as water from the shower might be used again for laundry and finally for landscape irrigation or toilet flushing. Such multiple use can reduce total household demand by 40 percent[48] On a community scale similar sequential uses seem feasible, although, outside of limited examples of irrigation, use of untreated industrial processing wastewater (such as in canning processes), and the secondary use of overflow from one agricultural field to another, few, if any, examples can be cited.

The limitations to this approach to water conservation are three:

- Acceptance by the public of secondary use of water for any purpose of which they are aware remains low. Studies have indicated, however, that use of lightly polluted water for certain limited uses is much more acceptable than any use of reclaimed sewage.[49] Indeed, there is evidence that during the drought years, many homeowners developed home water reuse systems (greywater systems) which went far beyond the recommendations and cautions of local health and water authorities.[50]

- Implementation of this approach would require modifications of existing plumbing systems to allow water to flow from one point of use to another before entering the sanitary drainage and may include interim storage facilities and possibly minor treatment. It would also probably require a procedure to monitor and maintain the system which would at least equal in complexity that which is required to maintain conventional wastewater treatment and reclaim water distribution systems. The cost of these modifications is not likely to be significant, and, in the absence of specific studies to analyze potential costs, any estimates would be highly conjectural. It does seem, however, that the costs would be substantially less than a sewage reclamation system capable of delivering a comparable amount of water. Furthermore, implementation could be accomplished incrementally in new construction or rehab of existing structures independent of the location or reclamation capability of the sewage treatment facility. Sequential secondary use of water should be given consideration as a cost-effective alternative strategy for enhancing water supply.

- The most efficient application of this approach would occur where sequential uses are located in relation to one another such that the need for pumping and the length of connections is minimized. This would add yet another factor in the already complex process of planning for spatial allocation of land uses. It would require a sophistication in facilities and land use planning which is far beyond the capability of most community planning bodies. It is not inconceivable, however, to have communities laid out, at least in part, on the basis of water flow through the community. Such a concept reinforces the need for stronger integration of land use, community development, and economic planning in conjunction with water management and allocation to complementary, as well as competing uses.

Ground Water Recharge, Conjunctive Use, and Greenbelt Irrigation

In arid regions, there is a tendency to rely on ground water sources rather than surface waters. This is due to the obvious reason that surface water is not always available and may not be reliable, even if near at hand. In addition, the cost of facilities to capture, store, transmit and distribute water can be high in relation to the cost of ground water extraction. As a consequence, water agencies often exceed the natural recharge rate of the aquifers they are mining.[51] Excessive drawdown of the ground water table results in higher pumping costs, which increase sharply with each additional foot of lift required to bring water to the surface,[52] as well as land subsidence and potential permanent contamination of the aquifer from salt water intrusion. In some instances, the ground water resource cannot accommodate the anticipated demand for water, and surface water is either not readily available or cannot be developed in time to augment the ground water source.

Water conservation can mitigate a problem of ground water overdraft in two ways. First, it can reduce the immediate demand for water and free whatever surface water may be available for ground water recharge, rather than requiring it for augmenting the water supply. Second, it is conceivable that water of secondary quality, such as household greywater, could be used directly for ground water recharge rather than contributing to the wastewater flow.[53]

Use of second quality water, either reclaimed sewage or diverted greywater flow, for ground water recharge raises the interesting possibility of linking water management policy and community growth policy in a very direct and tangible manner. Ground water recharge areas could be planned as permanent open space to define the boundaries of urbanized areas and set them apart, visually and functionally, from their neighboring communities. Ground water recharge areas, as a general rule, have to prohibit any substantial urbanization--due to the need to avoid any possible contamination of the aquifer and the need to avoid soil compaction which could reduce percolation of water through the soil.

Land disposal of treated wastewater has been practiced in a number of locations for years[54] and has attracted increasing attention with the stringent water quality requirements established in recent years.[55] In contrast to the development of a single large disposal area, as might attend conventional treatment and disposal methods, the proposal here is that the recharge or disposal areas be strategically distributed around the community to act as planned boundaries to additional growth. Increases in community population would be accommodated by increasing density within the community or within satellite communities, which are, in turn, defined by their own greenbelt. The use of diverted secondary quality water would have two distinct advantages over the use of reclaimed sewage.

First, it is conceivable that the secondary quality water could be used directly for irrigation and ground water recharge with little or no need for treatment before release. Second, water which is already dispersed by virtue of its point of source throughout the community will be more cheaply and readily distributed to the points of use around the community than a single point source at the regional wastewater treatment facility.

There are a number of constraints to the use of secondary quality water directly from point of source to irrigate greenbelts as ground water recharge areas. Perhaps most important is maintaining a monitoring program to assure that no potential health problem is created by irrigation areas which may be used for recreation by the general public with secondary quality water. Uncontrolled distribution of any untreated water poses a potential hazard which must be avoided by careful monitoring of the distribution system.

Mitigation of the quality problem might involve providing interim treatment or subsurface distribution, such as injection wells or drip irrigation systems, to minimize the potential for human contact.[56] The cost of these systems, as well as the collection and transmittal system from dispersed sources, is a major consideration which would have to be made relative to the value of the water provided by this system and the value of the open space as a ground water recharge area and community growth boundary.

In areas where ground water recharge is technically feasible, the multipurpose function of this approach provides an opportunity to establish a network of open space lands which might be politically unfeasible otherwise. The police power of the local planning authority can be combined with the pragmatic, technical objectives of the water agency to achieve mutually beneficial ends beyond the capacity of either acting independently.

Multi-jurisdictional Coordination

The ideal situation for integrating water policy and community growth policy is for a single governing body to have authority for both policies and for that body to have jurisdiction throughout the urbanized area. Unfortunately, it is all too common for the water authority and the general government responsible for land use planning to be separate entities. Furthermore, the jurisdictions of both water authorities and general government are often fragmented with several agencies of differing size, capability, and legal responsibilities operating side by side in a single metropolitan area.[57] The communities in these metropolitan regions, although served by different agencies, are often indistinguishable in terms of housing type, land use mix, socioeconomic status, geomorphic features, or delineation of community boundaries.

The authority, purposes, funding sources, and operational characteristics of water and sewer service agencies can differ greatly in accordance with the enabling legislation under which they were established. As a consequence, policies, service levels, rate structures, operating procedures, and relationship to the public serviced also differ greatly. Interagency cooperation between agencies of like function is often poor and, where like agency cooperation is poor, cooperation with the general governing agency is often very casual, at best.

In such an organizational environment, the varying policies with regard to community growth, water procurement and distribution, and water conservation will result in uneven, fragmented development potential within the region. Where the agencies draw from the same water source, be it ground water, surface water, or a combination, those agencies which encourage conservation would seem to be at a disadvantage. Assuming that the net marginal cost of increased pumping is less than the cost of instituting new conservation methods,[58] those agencies not instituting water conservation programs could, all else being equal, provide water at a lower price than those agencies which do.

Water agencies and sewer agencies typically lack the police power to affect land use within their jurisdiction, as do general governments with their zoning and planning powers. Therefore, water and sewer agencies are not in a position to influence land use and development to correspond to their own facilities' planning. Conversely, the local general government may have land use control, but in instances where water or sewer service is provided by an independent single purpose agency, they have no control over the extension of these services.

The ultimate resolution of this problem of diffused authority would be consolidation of the service agencies and the general government into a single multi-purpose government. Such a consolidation should enhance cooperation and unify community growth policies. The major drawback to multipurpose government is selection of an appropriate scale. The government must be large enough to address issues of regional complexity and yet small enough to be perceived by local residents as an integral part of community life. This is a complex subject far beyond the scope of this paper, but for an interesting discussion of a possible approach to this problem the reader is referred to Hagman's concept of "regionalized-decentralism."[59]

APPROACHES TO MANAGING COMMUNITY GROWTH

Manipulation of sewer and water service has become a favored tool among local governments wishing to influence the rate, type, direction, or total amount of urbanization.[60] Many formalized growth control policies include at least some reference to the potential influence of water and/or sewer controls in the community development process. The use of water and sewers in growth-regulating strategies is effective in controlling urbanization because the service is not ambiguous; i.e., it is either available, or it is not. In contrast, many other urban services, such as fire, police, and health care, may be available throughout an area, but the level of service can be adjusted by policy, and the service area can be expanded or contracted without any change in actual service capacity.

Virtually every community has in effect some form of policy on community growth. The policy may be no more than a tacit consensus of the governing body's favoring or opposing additional growth. Even where a community growth policy has not been formalized, most jurisdictions operate land use controls which, in other communities, have been recognized and articulated as tools for regulating community growth.[61] Examples include land use zoning, subdivision regulations, capital improvement programming, and water supply decisions.

There are essentially three approaches which have been utilized by communities to intentionally influence community growth with availability of sewer or water service. The first is to impose a limit on total community growth by failing to provide adequate water supply or sewage treatment capacity to accommodate any additional population beyond a foreseeable limit. Such a "no growth" policy might be manifest as a refusal of a governing board or city council to authorize the construction of a new water project or treatment plant facility. In other cases, such as Marin County in 1971,[62] proposals to augment capacity have been submitted to the voters and soundly defeated.

The effect of conservation on a total limitation of water supply or sewage capacity is to extend the supply or capacity so that it can accommodate more growth. As illustrated by the example of the Pacheco Valle project, cited above,[63] the effect of water conservation in extending water supply to accommodate additional dwelling units can be quite significant.

The second approach is to permanently withhold water or sewer service in a given area due to a specific non-development policy of the local government. Such policies are typically based on special characteristics of the land which render it unsuitable for development, such as periodic flooding, unstable or overly steep slopes, or very high potential for agricultural use.[64] Water conservation practices would have no effect on altering policy to extend service into such areas.

The third approach, and unquestionably the most sophisticated, is to make selective extensions of water of sewer service into certain undeveloped areas on the basis of a predetermined time frame or the occurrence of certain events. This approach might be called a "phased growth strategy" or "performance-standard growth regulation." Sewer and water service are not to be permanently withheld from these areas, but the decision of when and where to extend utilities is made a discretionary act of the governing body. The criteria used to make these decisions vary with each community, but they generally take into consideration the fiscal capacity of the government to service new development and overall efficiency of the service system. The capital improvement program developed by many local governments to plan major infrastructure improvements (typically streets, sewer, water, and public buildings)[65] is a de facto community growth regulation.

If water and sewer service are being sequentially extended into certain areas as a means to control community growth, water conservation would seem to have little potential effect on the process. Conservation throughout the system means the capacity of the entire system is increased, and, therefore it might allow the water agency to go ahead and extend service in advance of a predetermined schedule. Presumably, however, the policy decision to extend service in a sequential manner is based on many other factors and not on incremental additions of water to the total supply. Therefore, the increase in total supply simply means that the ultimate extension can serve more territory, or higher density, not that the next increment of service extension should proceed.

CONCLUSION

There is nothing new in recognizing the strong relationship between water and sewer services and land use. Goodman and Freund, in reference to a work published in 1962 by Stuart and Weiss,[66] stated:

> ...little attention has been paid to alternative policies concerning design, location, and timing of utility systems to guide new growth in a predetermined direction. What has been known intuitively for some time has been substantiated by research: that the provision of utilities often acts as a triggering device influencing the direction and rate of land development.[67]

In the decade which has passed since these words were published, we have begun to see the intentional integration of water policy and land use policy as a means of directly influencing the community growth pattern.

It is clear that the relationship between water policy and land use is fairly direct, but not always simple. A number of issues pertaining to the particular use of water conservation techniques as a water policy tool have been raised here; certainly there are others. It is characteristic of these issues that they strongly overlap with one another and that they involve one or more of the parameters set out above as determinants of water availability for community growth.

The success of the programs set up in various communities to control growth is mixed. In many cases, it is much too early to tell how they will actually work and what effects they may have. Also, in many cases it will be difficult to measure success because the objectives of the policies have never been quite clear. The chief limitation to effectively linking water policy to land use policy is the apparent failure to take the necessary comprehensive view of a complex and broad problem area. Einsweiler, in a study of 11 prominent growth management systems published in 1975,[68] drew the conclusions (among several others) that:

- Most of these systems have a problem solving orientation and give little consideration to the side effects of system operation

- Most of the systems tend to ignore levels of government other than the level of the agency proposing the system, and many even tend to ignore neighboring agencies of similar purpose

- There is relatively little research on the effects of land use controls in operation. No body of knowledge or insight is being recorded for future use by the operating agencies themselves, and no comparative evaluations across systems have been made

The key conclusion is that the truly unique contribution made by the more successful management systems is the integration of control elements.

The effective combined application of water policy and land use policy to influence community growth depends on four key elements.

- Adoption of a community growth policy. Foremost among the prerequisites is articulation and adoption of a clear, comprehensive community growth policy. Such a policy should be comprised of a detailed statement of opportunities and constraints for community development, community development objectives, and a strategy for implementing these objectives.

- The ability to monitor factors influencing community growth. Information on general trends in the community, the status of community resources (such as the availability of land and water), the effects of external influences, and the effects of internal community policies is essential to making informed, rational decisions on community policy. Of particular importance in matters of water and land use policy are the water consumption patterns of various land users in the community and the changing pattern of land use. Assumptions about water consumption patterns need to be verified by empirical data to avoid counterproductive policy decisions. For example, water use for agricultural purposes may be higher than water use for residential purposes on a per-acre basis. Many American power plants, metallurgical works, and chemical facilities in the Western States have perfected techniques for water conservation while achieving competitive costs of production, so the often-quoted industry norms for water use can no longer be offered as a valid basis for determining water demand in developing areas.

- Ability to integrate policy and implementation. The government agencies which influence community growth, at the very least, on a local level must be able to coordinate policies and programs as a single unit. Functional as well as political consideration of governing bodies is essential to avoid fragmented and contradictory influences on community growth.

  Single purpose agencies typically have not the inclination or resources to look beyond a narrow definition of public responsibility. The effective management of community resources to achieve community objectives, regardless of what those objectives might be, requires multi-service government capable of balancing conflicting objectives into a directed policy and acting upon it.

- Innovation and flexibility in water use and land use. "Necessity is the mother of invention." As long as water and land are a relatively plentiful resource, the inducement to use them casually is strong. As these resources become more dear, we can anticipate the use of them will be marked by increasing innovation. One possible trend will be attempts to match land use mix with available water supply. Not only residential use, but all land uses will be evaluated in terms of potential water demand and conservation. Water use characteristics will be a significant consideration in formulating a community general plan.

  Second, the feasibility of direct use of second quality water for low-priority uses in a sequential flow from initial point of use to ultimate treatment and/or disposal should be explored. The possibility of using second quality water for ground water recharge and simultaneously for community delineating greenbelts is highly attractive.

  Third, the concept of sequential use water flow suggests that certain land uses might be arranged to optimize the flow of water from one use to another. Thus, the general plan might consider not only the total acreage of each land use category in the community, but the spatial location of these land uses in terms of their water requirements relative to their neighbors.

  Fourth, and finally, we may see an increasingly strong link between community-wide policy and development project design in the matter of water use. The essence of residential water demand is the consumption habits of individual households. We can anticipate that conservation-oriented water agencies will exert whatever inducements or leverage is available to them to influence the design of new development such that their available water supply can be observed and extended.

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11. Milne, *op. cit.*, p. 19.

12. Milne's figures are somewhat low relative to the figures cited earlier in the paper for various locations in California. But, they are approximations which average out variation from season to season and year to year.

13. Milne, *op. cit*., p. 158.

14. Refer to the cases of Marin and Sacramento Counties (Notes 8 and 9) which were not atypical of many areas during the drought.

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26. This project was ultimately known as Pacheco Valle. At the time of this writing, it has gone into the second phase.

27. North Marin County Water District. *Water Service Facilities Construction Agreement*. Novato, California, February 1975.

28. Bradbury, 13 November 1978.

29. Johanna Hirst and Thomas Hirst. "Capital Facilities Planning as a Growth Control Tool and a Case Study of Metropolitan Washington, D.C.," *Management and Control of Growth*, vol. 2. Washington, D.C.: The Urban Land Institute, 1975, p. 461.

30. The feasibility of using individual septic tanks for household waste disposal and onsite wells for domestic water supply varies according to the soil and substrata conditions, availability and quality of ground water, and household water consumption habits. As a general rule of thumb, allowing for adequate spacing between wells and leach fields, autonomous water systems using *conventional* technology could not be used at a density greater than one dwelling/three to five acres.

31. Peter Warshall. *Septic Tank Practices*. Bolinas, Ca.: Mesa Press, 1976, p. 66.

32. *Federal Water Pollution Control Act* (Clean Water Act), U.S. Code, vol. 33, secs. 466 *et seq.*

33. The centralizing tendency is evidenced in many of the regional areawide waste treatment management plans developed under Section 208 of Public Law 92-500.

    The present development of "208" wastewater management plans provides the ideal forum for addressing the issue of centralized v. decentralized systems. Despite the fact that the "208" legislation requires that consideration be given to "alternative" methods for treatment, the basic planning approach has focused on conventional treatment methods and has strongly reinforced the trend toward large-scale centralized systems.

34. A number of issues regarding reduces flow in waste lines remain to be answered. For a partial inquiry, see John Nelson, "Change in TDS (Total Dissolved Solids) Concentration Resulting from Use of Low Flush (3½ Gal/Flush) Toilets in New Residential Construction, "North Marin's Little *Compendium of Water Saving Ideas*, Novato, Ca.: North Marin County Water District, 1976, p. 204. Also see U.S., Environmental Protection Agency, Office of Research and Development. *Renovated Wastewater as a Supplementary Source for Municipal Water Supply: An Economic Evaluation*, by Robert M. Clark. Cincinnati: U.S. Environmental Protection Agency, October 1976.

35. John McMahon. *Property Development*. San Francisco, Ca.: McGraw-Hill Book Company, 1976, p. 276.

36. William I. Goodman and Eric Freund. *Principles and Practice of Urban Planning*. Washington, D.C.: International City Manager's Association, 1968, p. 233.

37. Such interim measures were common during the 1976-77 drought in California. At one point, a temporary pipe was placed on the roadway deck of the Richmond-San Rafael Bridge over San Francisco Bay to deliver water from the East Bay to Marin County.

38. University of California, Agricultural Issues Task Force. *Agricultural Policy Challenges for California in the 1980's, Special Publication 3250*. (Berkeley, Ca.: University of California, 1978, p. 2.

39. An example of the adjudication process for determining water rights is given in Stephen C. Birdlebough and Alfred Wilkins, "Legal Aspects of Conjunctive Use in California," *California Water*.

40. Other ground water rights used in California are overlying rights (similar in concept to riparian rights in requiring beneficial use and direct physical proximity of source and point of use) and prescriptive rights, which come into existence when appropriations of ground water

are made to the detriment of other overlying or appropriative holders and continue for more than five years. Although it can be preceeded by overlying and prescriptive rights, most municipal services and water companies supplying domestic water were established for the exercise of appropriative rights. See Birdlebough. op. cit.

41. "Beneficial" is ill-defined in virtually all water law. In most instances, it has been interpreted as economic value. See California, Constitution, art. 14, secs. 3 and 100.

42. Rosaleen Bertolino. Water Supply: Constraints and Opportunities San Francisco, Ca.: Sierra Club, 1977, p. 17.

43. University of California, Agricultural Issues Task Force, op.cit., p. 20.

44 P.H. McGauhey. "Waste Water Reclamation--Urban and Agricultural," California Water, op,cit., p. 161.

45. W.H. Brurold. Public Attitudes Toward Reuse of Reclaimed Water. Berkeley, Ca.: University of California, 1972).

46. McGauhey, op.cit., p. 167.

47. Milne (1978), op.cit.

48. Ibid.

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51. California Department of Water Resources. Meeting Water Demands in Sacramento County, Bulletin 104-11. Sacramento, Ca.: California Department of Water Resources, June 1975

52. Edwin Roberts and Robert Hagan. Energy Requirements of Alternatives in Water Supply, Use and Conservation: A Preliminary Report, California Water Resources Center Report No. 155. Davis, Ca.: December 1975, p.4.

53. Maxwell Small. Meadow/Marsh Systems as Sewage Treatment Plants. Upton, N.Y.: Brookhaven National Laboratory, November 1975.

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57. This is particularly true in metropolitan areas of California which rapidly urbanized after World War II. In the metropolitan area of Sacramento County, for example, there are currently 18 water agencies; the smallest covers less than one square mile.

58. This is not necessarily the case. There are several factors which affect the relative costs of the alternative approaches.

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64. In California, such considerations are often included in the General Plan elements as specified in State law, *California Government Code*, Section 65300, *et seq*.

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Water Conservation Through Wastewater Reuse

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California State Water Resources Control Board

The 1976-77 drought in California focused attention on several management options to meet the water needs of agriculture, industry, and the cities. These options include measures to reduce consumption, water exchanges and transfers, conjunctive use of ground and surface waters, cloud seeding, and water reclamation. While the drought highlighted then need for water reclamation, this is by no means a water management option for drought years only, but should be considered as an integral part of the development of California's water resources. The purpose of this presentation is to describe the role that water reclamation has played and will be playing in the management of California's water resources and to discuss some of the constraints to water reclamation.

WATER SUPPLY AND DEMAND IN CALIFORNIA

In 1972, California had a net water demand of 31 million acre-feet (ac-ft) (Figure 1). (One acre-foot covers 1 acre of land 1 foot deep and is equivalent to 326,000 gallons.) Of this demand, 2.6 million ac-ft were obtained from undependable supplies, such as overdrafting of ground water basins and importing from areas that will not be able to export water in the future. In 1977, the second year of the drought, the shortage was a staggering 10.8 million ac-ft and was met mainly by ground water overdraft. By the year 2000, the California State Department of Water Resources projects the demand will be 39.4 million ac-ft with an annual shortage of about 4.3 million ac-ft. This projection includes water supplies from several controversial water development projects, such as the Peripheral Canal, and several reservoirs in the Central Valley, including Auburn Dam. The shortage could reach 6.3 million ac-ft annually if these projects are not implemented.

Californians produced about 3.1 million ac ft-of treated wastewater in 1975. This is likely to increase to 4.7 million ac-ft by the year 2000. All of this is not reclaimable because the high content of salts or other constituents make reclamation uneconomical. But by the year 2000 about 2.5 million ac-ft could be reclaimed in areas that now discharge into marine or estuarine water. Reclaiming this wastewater could significantly reduce the statewide water shortage.

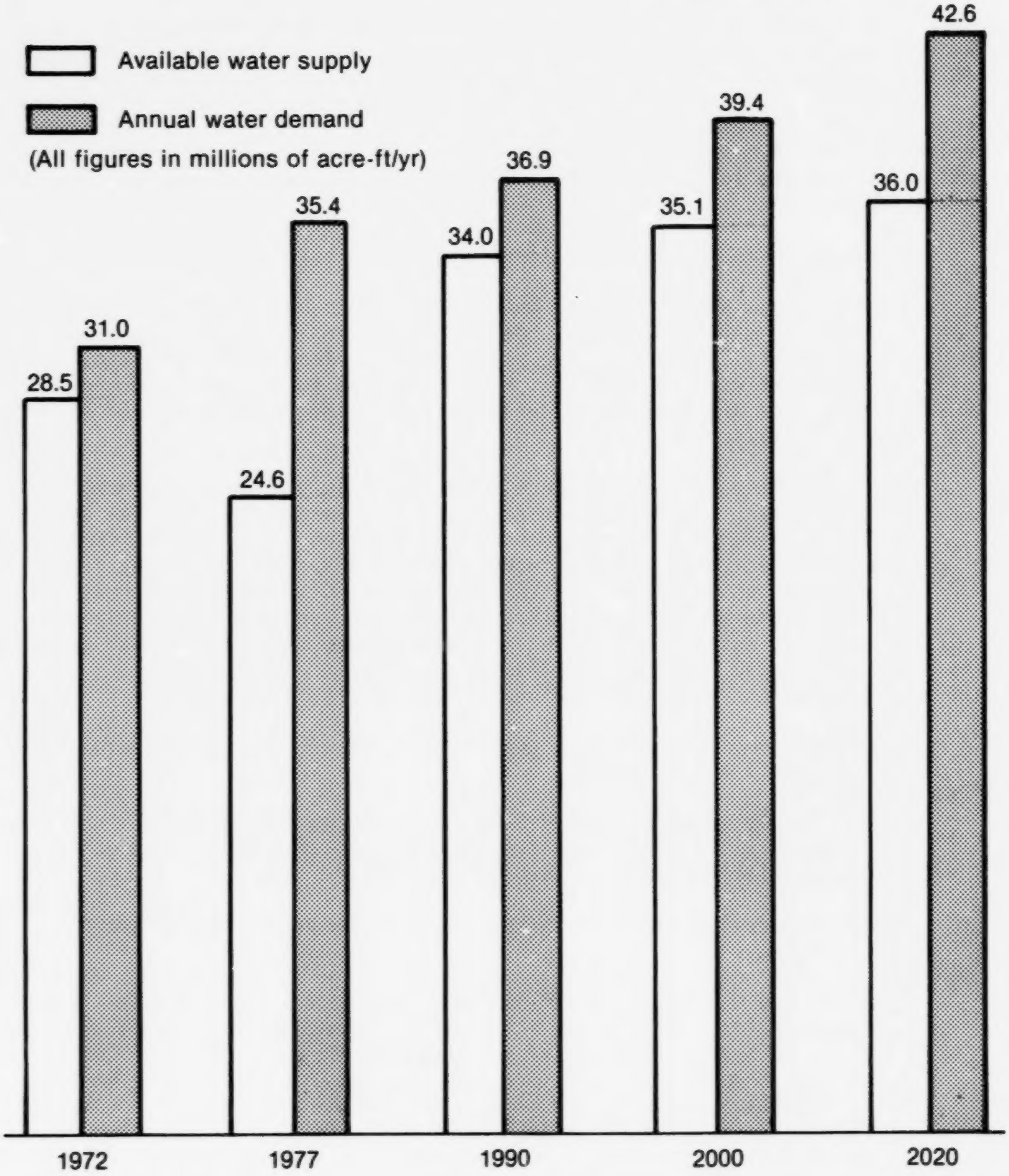


Figure 1. Water Supply and Demand in California.

BENEFITS OF WATER RECLAMATION

What benefits can be derived from the use of reclaimed water? To understand how these benefits can be derived, one must first understand the complex water picture in California. Two-thirds of our people live in the southern third of the State. Two-thirds of the rainfall occurs in the northern third of the State. And the most productive agricultural land in the nation, the Central Valley, lies inland in the middle third. The history of water development has seen water moved from where it is surplus in the northern and eastern mountains to the Central Valley and the populated plains and coastal areas of the south.

Using reclaimed water in California can:

- create new water supply. Water-short areas have resolved their water needs by moving surplus supplies from naturally water-rich areas. California is reaching the point where surface water surpluses are more difficult to identify, more expensive to transport to areas of need, and are subject to environmental considerations as to their availability.

  In the metropolitan Los Angeles-Orange County area of southern California, 1.1 million ac-ft/yr are discharged to municipal sewers for conveyance to a treatment or reclamation plant. Approximately 500,000 ac-ft/yr are considered economically reclaimable by reason of location and quality. Of the 500,000 ac-ft/yr considered reclaimable, some 50,000 ac-ft/yr, or 10 percent, are now being reused. An areawide water reuse study is now under way to establish the engineering and economic feasibility along with an implementation plan for maximum practicable reuse of the remaining 450,000 ac-ft/yr.

- improve water quality. The water quality effects of reuse in California are twofold:

  a) reduce or eliminate wastewater discharges which contain the associated heavy metals, chlorinated hydrocarbons, and other chemical compounds, into surface waters, and

  b) reduce freshwater imports, equal in amount to the volume of reuse.

  Along the coastal plain of southern California the ultimate effect of reuse could be as much as a 35 percent reduction in ocean discharges and a 25 percent reduction in freshwater imports. Some of the important benefits of reuse are indirect and are received in distant watersheds. The indirect effects are related to reduced freshwater diversion from the Sacramento-San Joaquin Delta. It has been estimated that water reuse as a statewide program can augment Delta outflow during critical dry years by 25 to 50 percent and preserve or enhance the delicate salinity balance in the Sacramento-San Joaquin Delta.

- Conserve energy. The energy required for pumping imported water a-across the Tehachapi Mountains from northern California or transporting it from the Colorado River to the heavily populated southern coastal plain is enormous. In 1975 the State Water Project alone used enough energy--3,865,000,000 kilowatt hours--to meet the needs of a city of 650,000. For example, the total energy cost for delivering one ac-ft of State Water Project to the Orange County Water District is 3300 kilowatt hours. In comparison, to reclaim one ac-ft of secondary treated wastewater, using complete tertiary treatment, requires 1550 kilowatt hours/ac-ft--less than half of that required for importation.

- Help protect wild and scenic rivers. More than 25 percent (about 18 million ac-ft of the total stream runoff in California is set aside and not available for water supply development under exisiting law for wild and scenic rivers in the north coastal area of California. To the extent that water reuse reduces the need to construct reservoirs on these river systems, the effect will be to preserve exisiting streamflow regimes, wildlife habitats, and recreational values.

- Reduce water cost. New surface water reservoirs developed in California will cost substantially more than previous ones. Estimates of the economic value of large-scale reuse in southern California range from $200 to $300/ac-ft, in terms of the capital cost of equivalent reservoir yield and the marginal cost of delivery to southern California. In Marin County, an area hard hit by the recent drought, costs of reclaimed water, primarily for landscaping uses, are estimated to be approximately $167 to $284/ac-ft for three reclamation projects now being planned. New alternative domestic supplies for Marin County are estimated to cost approximately $300 to $316/ac-ft. These examples serve to point out that in water-short areas reclaimed water can significantly reduce the cost of a new water supply.

OFFICE OF WATER RECYCLING

In October 1977 Governor Brown created the Office of Water Recycling (OWR) within the State Water Resources Control Board in order to accelerate water reclamation in California. At the same time the Governor established a five-year statewide goal to triple the use of reclaimed water by 1982 from the present 184,000 ac-ft/yr to 600,000--an amount equivalent to two-thirds of the water needs of the City of Los Angeles.

To accelerate and encourage water reclamation activities, OWR has developed a four-point strategy:

- Concentrate on large-volume uses of reclaimed water, such as agricultural and landscape irrigation, power plant cooling, and ground water recharge

- Emphasize uses with fewest constrints, such as industrial uses where public health considerations can be minimized

- Encourage reclamation through grants from the Clean Water Construction Grants program for water reclamation facilities

- Inform potential users of reclaimed water of recent scientific and engineering developments by serving as the State's focal point for information exchange and public education in the area of reclamation.

WATER REUSE IN CALIFORNIA

Wastewater reclamation is not a new concept in California. As early as 1918, the State Board of Public Health adopted specific regulations for the use of treated sewage effluents for crop irrigation. The use of reclaimed water has steadily increased, and today 184,000 ac-ft/yr are used by industry (2 percent), for agricultural (65 percent) and landscape irrigation (17 percent), for recreational lakes (1 percent), and for ground water recharge (14 percent) (Table 1).

Presently, in the California Clean Water Construction Grants Program, 116 reclamation projects are in various stages of planning, design, and construction. Twenty-one projects have been completed and are providing 130,000 ac-ft/yr of reclaimed water for a variety of uses. If all of these projects are successfully implemented, over 500,000 ac-ft/yr of reclaimed water could be on-line by 1982 (Table 2). As nearly two-thirds of the wastewater generated in California is produced in the heavily populated urban centers, there is a large increase in the amount of reclaimed water planned for such typically urban needs as landscape irrigation (Figure 2).

CONSTRAINTS ON REUSE

While the need to expand the use of reclaimed water in California is clearly evident, there are major constraints which must be resolved before implementing large-scale wastewater reclamation. The complex constraints to be overcome involve economic and environmental costs, institutional restrictions, and social questions. Independently they pose significant questions which must be answered. Collectively their interrelationships further complicate attempts to find solutions to the questions posed.

- Economics. There are three major economic constraints to increased water reuse in California:

    a) The cost of most of the present freshwater supply is relatively low, which is due mainly to the supplies coming from the most easily developed sources.

    b) The price of freshwater the consumer pays is highly subsidized (a number of agencies which operate development facilities charge customers only a fraction of the cost of water. Indeed, some retail purveyors use property taxes to reduce the price charged customers).

TABLE 1. WATER REUSE IN 1978

Type of use	Number of operations	Acre-feet/ year
Agriculture	216	120,000
Landscape irrigation	104	31,000
Groundwater recharge	4	26,000
Industry	21	4,000
Recreational impoundments	13	2,000
Other	2	1,000
Total	360	184,000

TABLE 2. GRANT PROGRAM RECLAMATION PROJECTS IN CALIFORNIA
OCTOBER 1978

Current status	Number of projects	Reclaimed water flow, acre-feet/year
Planning	72	292,160
Design	14	36,920
Construction	30	54,510
Construction completed	21	130,130
Total	137	513,720

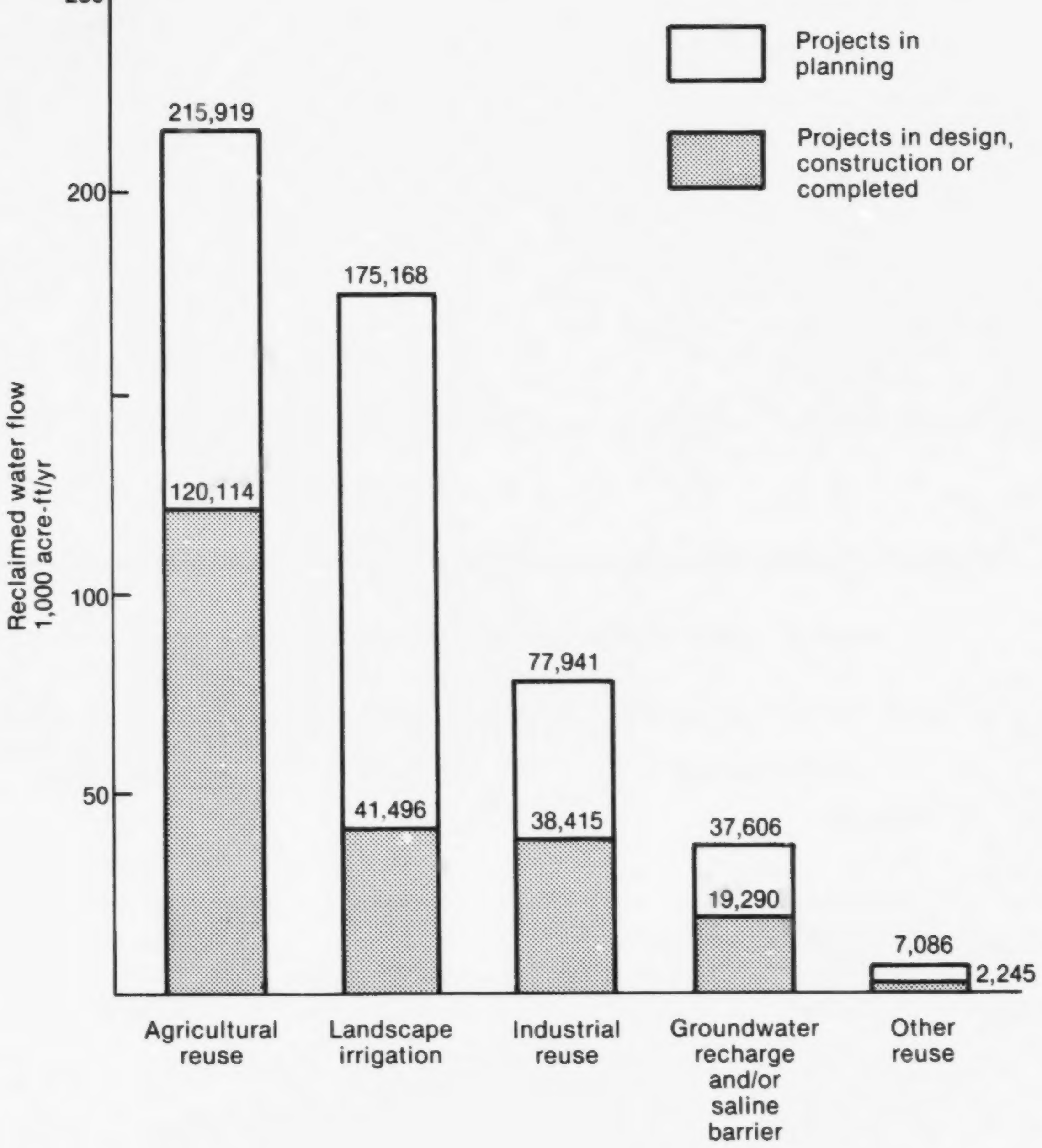


Figure 2. Reclamation in the Clean Water Grant Program, October 1978.

c) The cost of using reclaimed water in many cases is substantial.

While treatment of wastewater to levels required by permits can be written off as pollution control expenditures, any additional treatment and the delivery system required for reclaimed water make its cost substantial. An added cost of using reclaimed water of a lower quality than freshwater may be incurred in terms of yield decrements or lower production efficiency. Since the great majority of the reuse potential lies in replacing freshwater, reclaimed water usually must be price-competitive as well as cost competitive with freshwater. When all three constraints are present in a reuse situation, a formidable barrier presents itself.

However, from the State viewpoint the total cost of reclaiming wastewater in most cases is less than the total cost of developing new freshwater supplies.

- Health risks. Technology is available today to treat sewage so that it meets traditional drinking water standards with respect to microbiological, chemical, and physical quality. Not enough is yet known about virus removal, the long-term carcinogenic effects of ingesting trace organic chemicals, and the accumulative effects of heavy metals. An overriding consideration is the reliability of present-day technology and processes to provide reclaimed water that continuously meet accepted standards. The reliability question has been answered to a large extent for a price, by requiring redundancies, back-ups, and fail-safe systems in treatment plant operations. Further research research is needed to evaluate and improve the capability and reliability of treatment processes and equipment to consistently produce a uniform quality of reclaimed water.

Because of the major potential for using reclaimed water for ground water recharge, health criteria must be developed where reuse involves recharge of ground water basins serving as domestic water supplies. Several years ago in California, an expert consulting panel on health aspects of wastewater reclamation was established to guide State agencies in developing a research program to establish criteria and to plan and implement programs for the use of reclaimed water for ground water recharge. This research is now under way and should provide over the next few years a foundation of information and safeguards to allow increased water reuse in California without endangering public health or degrading water quality.

The farming community has been reluctant to use reclaimed water because of concern that the marketability of crops irrigated with reclaimed water may be reduced. Health regulations do allow the use of highly treated wastewater for irrigation of food crops, but many times the cost of such highly treated water is not competitive with other irrigation water The bulk of reclaimed water used in California agriculture is for irrigation of pasture, fodder, fiber, and seed crops where health concerns are minimized and where lower levels of water quality can be provided by less costly treatment schemes.

- Institutional/legal constraints. In most instances the agencies that develop, deliver, and regulate water supply are separate from those that collect, treat, and discharge wastewater. This is true for agencies at the local level as well as at the State and Federal levels. At the local level this presents a constraint because it is often difficult to bring together the wastewater treatment agency which produces the reclaimed water and the water purveyor who is usually the logical seller of reclaimed water. The constraint presented separation at the State and Federal levels is more subtle, but just as significant. For California, where the quantity of the water and the quality of the water are strongly related, such as separation presents a definite constraint, sometimes even at the policy level.

  There are laws in California that were originally instituted to protect water purveyors, but which now present a restriction on reuse of wastewater. For instance, one law prohibits the installation of a duplicate distribution system, required for delivering reclaimed water, without reimbursing the original water purveyor. Another institutional constraint to reuse is the adverse financial impact on water suppliers which may be caused by the use of reclaimed water in the supplier's service area. Suppliers in a certain situation can incur a revenue deficit and/or a loss of reclamation benefits.

  All of these constraints exist, because up to now there has been no accommodation for reclaimed water in the water supply business. As institutional and legal changes are made to bring reclaimed water into the total water supply picture, these constraints will disappear.

- Water rights. California law recognizes many kinds of water rights, but there are three basic types of water rights:

  a) Riparian right: the right of a property owner to take water from a natural stream or lake bordering that property for use on the riparian land (a right determined solely by location of the land with respect to water supply)

  b) Ground water rights: the rights of owners of land overlying a ground water basin to withdraw water for reasonable beneficial use on their overlying lands (another right determined by location of land with respect to water supply)

  c) Appropriation of surface waters: the right to take surface water and apply it to a beneficial use (a right granted according to the "first in time, first in right" doctrine by which priority of water use, in time of shortage, is given the user who has had the right the longest).

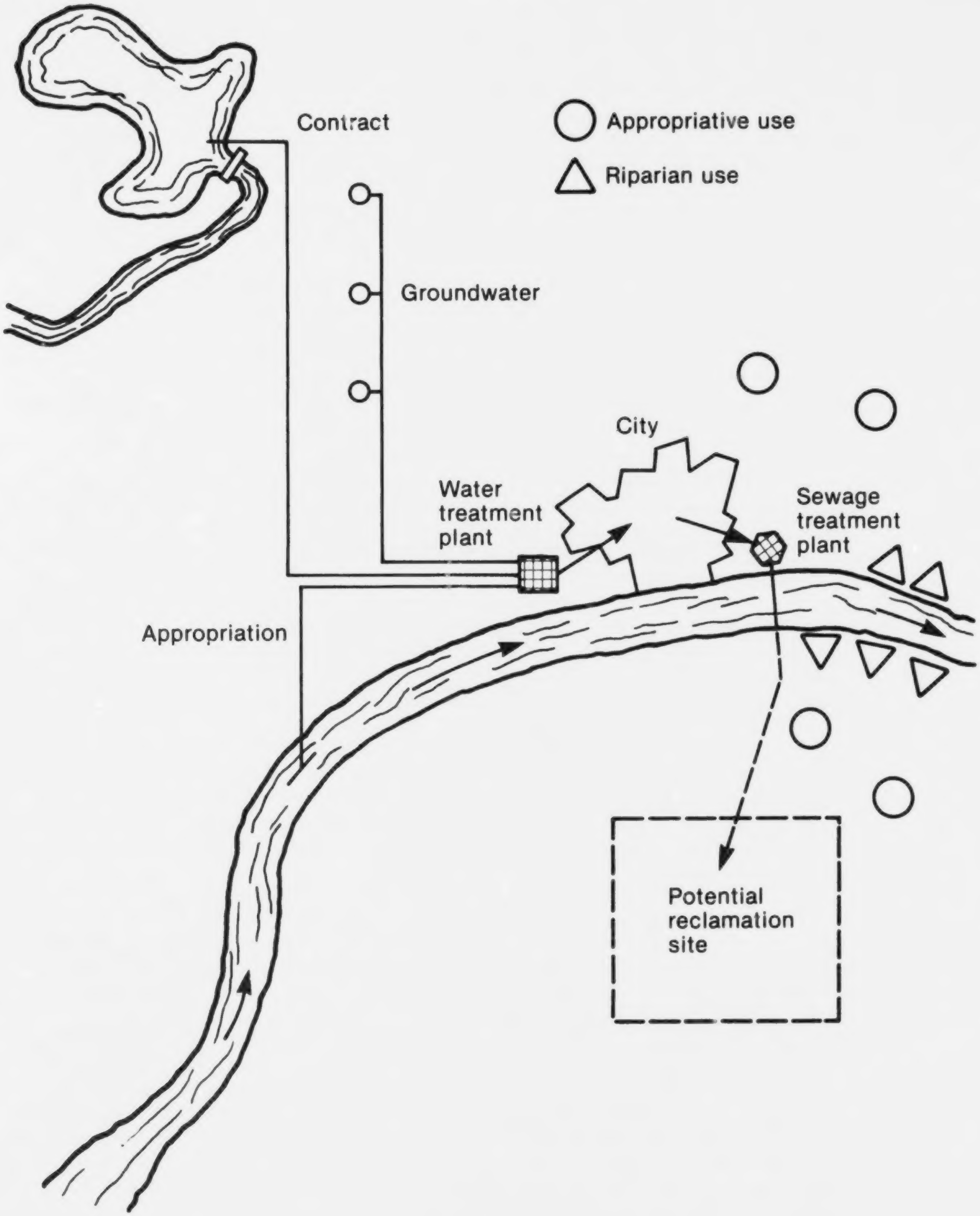
  Under California law it has become apparent that the sale and distribution of reclaimed water may raise water rights questions regarding the ownership of the resource. These problems will arise both prior to the treatment of the water and subsequent to its discharge. Prior to treatment, a wastewater treatment facility may receive the wastewater from local sanitation districts. These districts normally convey the water through a sewage collector system after it has been discharged by local municipal and industrial users. These local users receive their water from a municipal water supply system, a private water company, or through their own diversions (Figure 3). The water may be used on the basis of ground water rights, surface water rights, or contract rights with the U. S. Bureau of Reclamation or the State Water Project. It is unclear under existing law who--the owner of the wastewater treatment facility or the water suppliers--may rightfully claim ownership of the treated effluent.

Parties have commonly settled such questions through private agreements. In order to encourage the sale and distribution of reclaimed wastewater, it would be desirable to concentrate the ownership of the resource in one entity rather than in multiple entities. The Governor's Commission to Review California Water Rights recently urged that the owner of the wastewater treatment plant be granted the right to sell or distribute the reclaimed water.

The subsequent reuse of reclaimed water raises a different set of ownership issues. Commonly, downstream users will have obtained rights to the return flow that upstream users have discharged into the stream. Generally, upstream dischargers must respect the rights of downstream users to the return flow.

Two exceptions to this rule occur where the owner of a wastewater treatment plant initially discharges treated effluent with the prior intent of recapturing the water (i.e., a reclamation program is planned for implementation at some future date), or, where the source of the water is imported water, and the water is recaptured within the plant boundaries or the boundaries of the district, the treatment plant owner may be able to market that water to the detriment of downstream users. Existing law now provides substantial judicial consideration of downstream rights to return flow, thus creating a potential problem where the treatment plant owner proposes to produce and market reclaimed water.

- Public acceptance. Any program that considers the use of reclaimed water must take into account public attitudes toward such reuse and questions concerning protection of public health. A recent study by William Bruvold of the University of California, Berkeley, measured public attitudes toward 25 general uses of reclaimed water in California (Table 3). The use of reclaimed water for drinking and food preparation got the strongest opposition. The lowest level of opposition was directed to irrigation of golf courses and highway greenbelts, and road construction. The study concluded that the extent of opposition is correlated with the likelihood or extent of close personal contact. Fifty percent of the respondents in the study opposed the use of reclaimed water because the water was considered psychologically repugnant or lacked purity (Table 4). The public perceives that foul-smelling, bad-tasting, dirty water is likely to contain harmful organisms or substances and that clear



Contract
○ Appropriative use
△ Riparian use
Groundwater
City
Water treatment plant
Sewage treatment plant
Appropriation
Potential reclamation site

Figure 3. Water Rights.

TABLE 3. PUBLIC ATTITUDES TOWARD 25 USES OF RECLAIMED WATER

	Category of use	Percent opposed to use
1.	Drinking water	56.4
2.	Food preparation in restaurants	56.0
3.	Cooking in the home	54.5
4.	Preparation of canned vegetables	54.1
5.	Bathing in the home	38.7
6.	Swimming	23.7
7.	Pumping down special wells	23.2
8.	Home laundry	22.8
9.	Commercial laundry	21.9
10.	Irrigation of dairy pasture	14.1
11.	Irrigation of vegetable crops	14.0
12.	Spreading on sandy areas	13.3
13.	Vineyard irrigation	12.9
14.	Orchard irrigation	10.1
15.	Hay or alfalfa irrigation	7.5
16.	Pleasure boating	7.3
17.	Commercial air conditioning	6.5
18.	Electronic plant process water	4.9
19.	Home toilet flushing	3.8
20.	Golf course hazard lakes	3.1
21.	Residential lawn irrigation	2.7
22.	Irrigation of recreation parks	2.6
23.	Golf course irrigation	1.6
24.	Irrigation of freeway greenbelts	1.2
25.	Road construction	0.8

TABLE 4. REASONS FOR OPPOSITION TO USES OF RECLAIMED WATER

Reason	Percent stating reason
1. Psychologically repugnant	29.2
2. Lack of purity	21.5
3. Can cause disease	9.8
4. Bodily contact undesirable	8.0
5. Undesirable chemicals added	5.1
6. Taste and odor problems	3.9
7. Cost of treatment unreasonable	0.8

water, having no odor and a good taste, is likely not to be harmful. The goal of scientists, engineers, and health professionals in controlling the use of reclaimed water is to provide a reclaimed water of suitable perceptual quality for the intended use that is free from unacceptable risks posed by disease-causing organisms or substances. Thus, the key to developing public acceptance of reclaimed water is a strong public information and education program backed by solid scientific, engineering, and medical evidence gained through well-publicized research and demonstrations.

- Flow reduction/reclamation conflict. Individually, flow reduction and reclamation are proven methods to extend existing water supplies; however, when practiced simultaneously, these measures can act to cancel their individual advantages. Flow reduction measures can adversely impact the water quality and quantity requirements of a reclamation project to the extent that where stringent conservation measures are enforced, subsequent reclamation and reuse of the water supply is not possible.

  To further explore this conflict, consider the hypothetical situation illustrated by Figure 4. This figure shows a typical situation where a municipality draws its water supply from a reservoir, purifies the water, and delivers it to the various urban users.

  Following consumptive uses and losses to infiltration and evaporation, the remaining wastewaters are discharged to the sewer system, undergo treatment, and are discharged to a stream, land, or the ocean. Typically, municipal water use adds about 300 parts/million of total dissolved solids (TDS; i.e., salts) which are not removed during primary or secondary wastewater treatment. Generally, water with a TDS concentration of less than 500 parts/million can be used safely by a farmer or industrial concern, but at higher levels certain plants may suffer as a result of salt buildup in the soil, or scaling of pipelines can result. Generally, conservation of domestic water results in poorer quality reclaimed water because the pollutant load is carried by a smaller volume of water, resulting in higher constituent concentrations. Also, the quantity of reclaimed water available to the user is decreased. For the agricultural or industrial user in the hypothetical situation, if the user relies totally on reclaimed water, municipal conservation will affect the quantity and quality of the user's water. The user in this example may be forced to abandon, wholly or in part, his reclaimed water supply and replace or augment it with a quantity of the municipal supply.

  In summary, there may be cases where the implementation of flow reduction measures would worsen the user's reclaimed water quality, requiring significant capital costs to bring in fresh water for dilution. It is difficult to generalize about the cost or water quality impacts resulting from flow reduction or reclamation. Either water conservation alternative results in significant benefits. It is

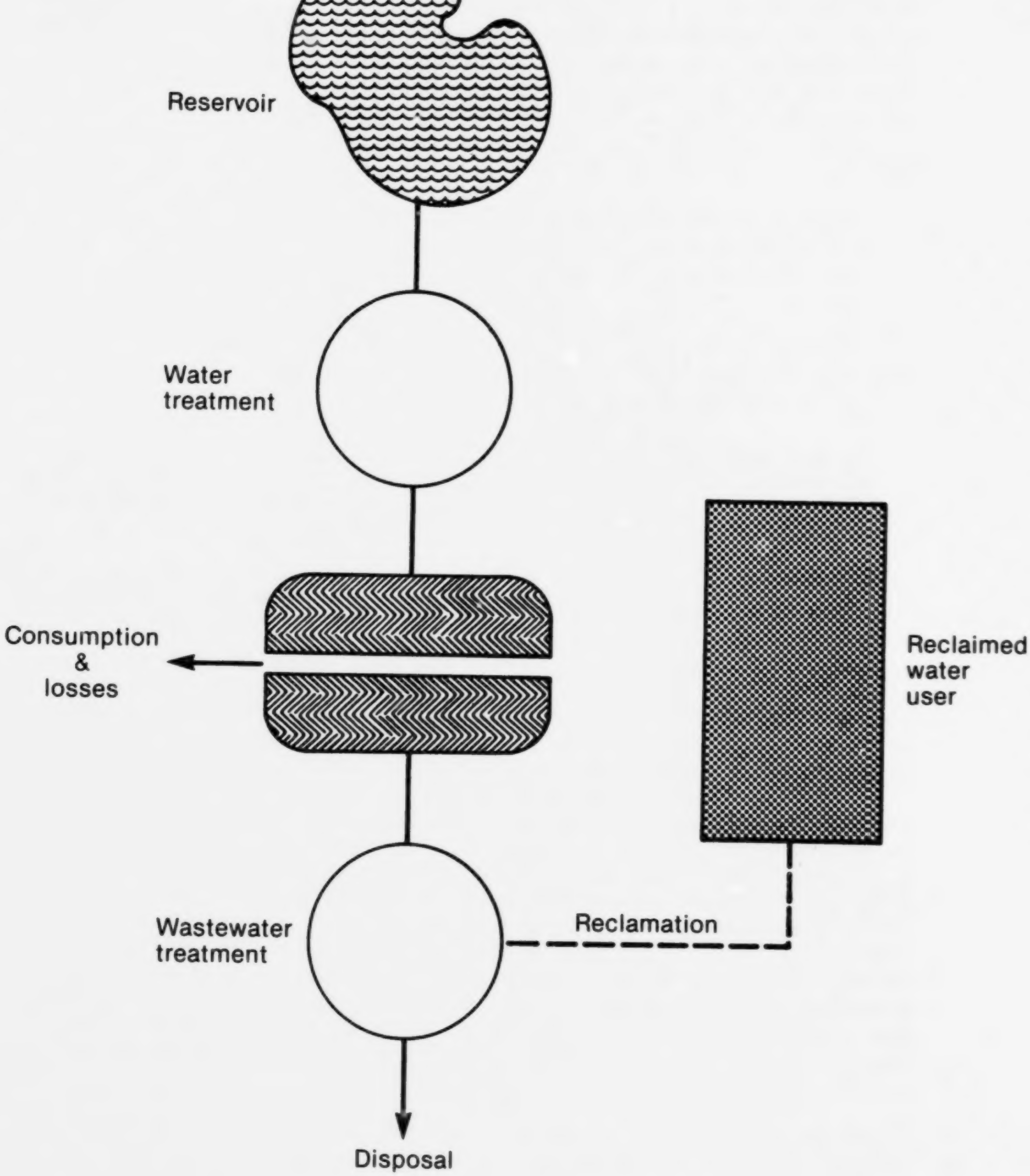

Reservoir
Water treatment
Consumption & losses
Reclaimed water user
Wastewater treatment
Reclamation
Disposal

Figure 4. The Flow Reduction/Reclamation Conflict.

therefore necessary to analyze feasibility of various water conservation alternatives and select the most cost-effective program for implementation.

INCENTIVES FOR REUSE

Why would agriculture, industry, or a municipality want to use reclaimed water? What are the incentives? The incentives for a particular reuse operation are dependent on local conditions; however, in general terms the incentives fall into five categories:

- Reliability of supply. Wastewater reclamation provides a dependable supply of water to the user year-round.

- Compatibility with water policies/legislation. The Federal Water Pollution Control Act requires the application of the best practicable waste treatment technology, including reclaiming and recycling water. Federal water policy now mandates that conservation measures be made mandatory for facilities receiving Federal grants. At the State level, legislation has been passed requiring the use of reclaimed water where economically and technically feasible in lieu of potable domestic water for landscape irrigation.

- Marketability of water. Municipalities, faced with major costs for effluent disposal facilities, have found that selling reclaimed water to various markets aids in offsetting the costs of wastewater treatment. Also, farmers realize savings in fertilizer costs by using nutrient-rich reclaimed water for irrigation.

- Reduced pretreatment needs. For industry, in-plant recycling and reuse means less wastewater to be treated and discharged to the sewer system--resulting in a savings of waste treatment costs.

- Lower sewer charges. Again, industrial recyclers realize significant reduction in sewer charges by reducing the quantity of wastewater discharged to municipal sewer systems.

The following case studies serve to illustrate these points for a variety of reclaimed water producers, users, and industrial recyclers.

- Burbank Power and Light. About 10 years ago, the City of Burbank was sending all its wastewater to the City of Los Angeles for treatment and disposal. To reduce the cost of wastewater disposal and to conserve water, Burbank built a 7 mgd sewage treatment facility with outflow from the plant going to supply the 1.2 mgd cooling water requirements of the Burbank Power and Light generating station.

  The cost of city-supplied water is much more expensive than reclaimed water. City water currently sells at $135/ac-ft, and reclaimed water at $25/ac-ft. In terms of costs for water purchase and chemical treatment to control pH, scaling, hardness, and coliform, total cost savings to the power plant amount to $6300/month.

- Simpson Paper Company. Simpson Paper Company's Shasta Mill near Anderson, California, operates under some of the most stringent water quality regulations in the United States. The regulations are tight because the mill discharges to the Sacramento River, a highly productive fish spawning ground. Wastewater discharges resulting from a plant expansion in 1974 could not economically be treated sufficiently to meet discharge standards, so the company investigated the use of secondary effluent for irrigating croplands.

  Presently the mill produces 2.6 mgd of reclaimed water for irrigation of 650 acres of cropland. A fully automated flood irrigation system is used to supply the water to the land, achieving good yields of oats, wheat, and field corn.

  This land has highly permeable soil, which allows the effluent to percolate rapidly to the riverbed. During the recent drought when Sacramento River flows were below 5000 cubic feet/second, the Shasta Mill was able to meet the most stringent conditions prescribed in its discharge permit.

- Irvine Ranch Water District. In 1972 the Irvine Ranch Water District (IRWD) adopted a Water Resources Master Plan which provided for maximum use of the District's total water resources, including fresh water supply, the collection and treatment of wastewater, and the extensive use of reclaimed water. In assessing options for disposing of its effluent--primary dependence on either reclamation and reuse or ocean disposal--the District opted for the total reclamation alternative. Two key points became evident in the analysis of the alternatives. First, the degree of treatment had become virtually the same for the two alternatives largely because of increasingly stringent water quality standards for ocean disposal. Second, the cost of the total reclamation program was $1.25 million less/year than the ocean disposal route--mainly because IRWD could earn a potential $4 million annually by selling reclaimed water. Presently, IRWD supplies 5 mgd of reclaimed water for irrigation of citrus orchards, vegetable crops, landscape irrigation in parks, community greenbelts, and golf courses.

  IRWD sells reclaimed water for $69.06/ac-ft, compared to the $143.75/ac-ft charge for Colorado River water imported for domestic uses. High in nitrogen and phosphorous, the reclaimed water is calculated to have a fertilizer value of $30/ac-ft, which at prevailing irrigating volumes comes to about $120/acre/yr. To the farmer this means fertilizer cost-savings on top of the water cost-savings obtained by purchasing reclaimed water at half the price of freshwater.

- Hewlett-Packard Corporation. An excellent example of in-plant water recycling is the Santa Rosa Division of Hewlett-Packard Corporation, which recycled 4 million gallons of water during 1977. The recycled water is used for irrigation of plant grounds, cooling tower make-up, and machinery cooling. Future plans call for reclaimed water to be used for toilet flushing for the firm's work force of over 1400 employees.

The industrial waste treatment and recycling program saves Hewlett Packard $30,000 yearly in reduced water and sewer charges.

CONCLUSIONS

In summary, let me review the key points discussed in my presentation. The benefits to be gained from water reuse are manyfold: creating new lower cost water supplies, conserving energy and natural resources, and enhancing water quality. It would be misleading to assume, however, that using reclaimed water does not bring with it serious concerns: economic constraints, institutional barriers and legal hassles over water rights, concerns over health risks, and public reluctance. It has been shown that in many situations wastewater reclamation and water reuse make sense. We are proceeding to encourage wastewater reclamation in California, but in doing so, we cannot neglect other methods of water conservation: water-saving plumbing fixtures, improved irrigation efficiency, and realistic water pricing. Water conservation through wastewater reuse can reduce the need for development of additional water supplies and can provide significant water quality benefits. In situations where reclamation and flow reduction measures may conflict, cost-effectiveness of the various management options must be assessed.

Water Conservation and Land Use Planning

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Harland Bartholomew and Associates

INTRODUCTION

The rate of water consumption in any given region is ultimately determined by a series of interacting decisions, ranging from the individual household member to the State or regional agency granting water withdrawal permits. There are, of course, many steps within this continuum, each with varying impact on the overall consumption rate.

The purpose of this paper is to examine ways in which land use and land use planning decisions influence water consumption and present water conservation opportunities. Whether these decisions are made by private landowners, by official planning agencies, or both, the potential impact on water consumption is great. Full awareness of this impact is an essential ingredient of any strategy for water conservation.

This paper is organized around two central questions:

- How do different land uses affect the hydrodynamics of a given watershed?
- How can the land use planner maximize opportunities for water conservation in the use and management of land and water resources?

The hydrologic/ecologic context in which water consumption and water conservation must be examined are first discussed, followed by a methodology for gathering hydrologic and land use data. Finally, criteria are described for evaluating data collected in terms of water conservation opportunities.

WATERSHED HYDRODYNAMICS

Our purpose here is to summarize briefly the principal components of watershed hydrodynamics, to identify some of the significant control points in the dynamic system, and to determine how different land uses and land use decisions influence these controls.

For our present purpose, it is important to visualize any given watershed as a bounded area with numerous hydrologic inputs, a capacity for dynamic storage, and numerous outputs. Figure 1 illustrates this generalized system schematically.

Inflow

Depending on the position in a particular watershed, inflow through streams, channels, rivers, etc., may account for the overwhelming share of total hydrologic input (as in the New Orleans Metropolitan Area), or it may account for only a very small portion (as in Rocky Mountain National Park). Annual precipitation and watershed area upstream of the region under consideration are the twin factors governing inflow. Engineering modifications in the watershed (dams, canals, relatively large withdrawal, etc.) may change the pattern of flow significantly; such modifications may also significantly change the total annual quantity of flow, particularly on smaller and/or drier watersheds.

Any strategy to conserve water at a regional level should include a careful assessment of total annual inflow, seasonal patterns of flow, inflow in relation to precipitation, modifications in the watershed which alter pattern and quantity of inflow to the region in question (including significant land use changes as well as channel modifications), and the probable magnitude and direction of inflow changes.

Precipitation

The importance of this input to the hydrodynamics of a watershed is self-evident. With the possible exception of urban "rain shadows" under recent investigation, cultural influences on precipitation are very small. Total annual precipitation in a region is a naturally determined (though not necessarily a constant) quantity.

Infiltration

This is one of the most critical hydrodynamic processes so far as water conservation is concerned, in that it determines the quantity of precipitation and snowmelt which enters the dynamic ground water storage component. Infiltration is also a process over which there can be significant cultural influence. Factors affecting the extent of infiltration include land slope, vegetation, soil texture, soil moisture status, rate of precipitation, depth to bedrock, and depth to water table. Land use and land surface management have a strong influence on infiltration, as shown in the subsequent section.

Runoff

Precipitation and snowmelt not taken into the ground by infiltration are lost to the immediate ground surface by runoff. This water may collect in shallow basins and percolate into the ground elsewhere in the watershed; it may enter ponds, lakes, or reservoirs in the watershed; or it may enter swales, streams, channels, rivers, etc., and leave the watershed as outflow.

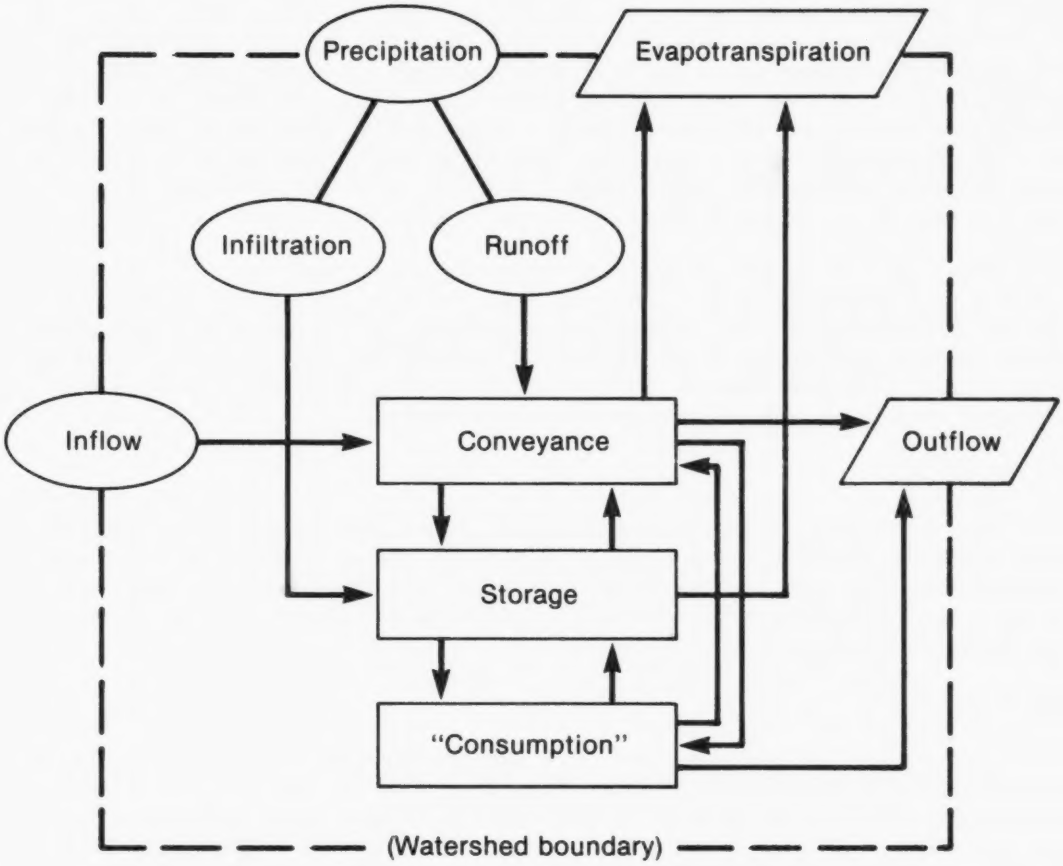

Precipitation
Evapotranspiration
Infiltration
Runoff
Inflow
Conveyance
Outflow
Storage
"Consumption"
(Watershed boundary)

Figure 1. Generalized Hydrodynamic Scheme for Watersheds.

There is often a dynamic ground water storage reservoir (aquifer) closely associated with the water conveyance systems. This may simply be sand and gravel deposits lining the channel which are well-connected hydrologically to the open channel itself.

One of the most significant hydrodynamic impacts of urban development is an increase in runoff caused by the construction of impervious surfaces. Runoff from urban land surfaces is generally two to five times that of unimproved land areas (see Table 1). Site design and surface management techniques can be altered to greatly decrease runoff, and these will be discussed at some length in a later section of this paper.

Evapotranspiration

Evapotranspiration is the combined loss of water vapor from land and water surfaces (evaporation) and from plant surfaces (transpiration). While the total quantity of water vapor lost each year from plant surfaces may be comparable to that lost from land and water surfaces, the relationship depends strongly on vegetation type and density, as well as physical properties and moisture content of soils.

The rate of evaporation and transpiration from any given surface is determined by the difference in water vapor pressure between the evaporating (or transpiring) surface and the surrounding air. This difference in vapor pressure is generally enhanced under sunny conditions, when direct solar radiation elevates soil and plant surface temperatures well above air temperature, thereby increasing the vapor pressure difference. Furthermore, regions with consistently sunny climates also tend to have drier air, thereby further increasing the vapor pressure difference between evaporating surfaces and air.

Water Consumption

It is important to examine overall "consumption" of water within a watershed. In many cases "consumption" simply refers to a temporary diversion of water from surface or ground water reserves to industrial, residential, or agricultural uses, some or all of which may be returned to storage or conveyance systems within the watershed. In certain industrial uses, sizable quantities may be exported from the watershed for ultimate consumption or discharge elsewhere.

In estimating total water consumption by different land uses, it is reasonable to assume that each person in residential areas uses 75 gallons/day (gpd). Regionally-determined data may reveal significantly different averages, particularly in response to water conservation programs. Industrial water consumption is highly industry-specific, but Table 2 shows ranges and estimates for selected industries. Consumption through irrigation is too variable for generalized estimates.

TABLE 1. TYPICAL RUNOFF COEFFICIENTS FOR DIFFERENT LAND USE TYPES

Land use type	Runoff coefficient
Business	
Downtown	0.70-0.95
Neighborhood	0.50-0.70
Residential	
Single-family	0.30-0.50
Multiunits, detached	0.40-0.60
Multiunits, attached	0.60-0.75
Residential suburban	0.25-0.40
Apartment	0.50-0.70
Industrial	
Light	0.50-0.80
Heavy	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Railroad yard	0.20-0.35
Unimproved	0.10-0.30
Character of surface	
Pavement	
Asphalt and concrete	0.70-0.95
Brick	0.70-0.85
Roofs	0.75-0.95
Lawns, sandy soil	
Flat, up to 2% grade	0.05-0.10
Average, 2-7% grade	0.10-0.15
Steep, over 7%	0.15-0.20
Lawns, heavy soil	
Flat, up to 2% grade	0.13-0.17
Average, 2-7% grade	0.18-0.22
Steep, over 7%	0.25-0.35

Source: Hjelmfelt and Cassidy, 1975. Hydrology for Engineers and Planners, page 114.

TABLE 2. WATER CONSUMPTION BY SELECTED INDUSTRY TYPE

Process	Consumption
Cannery	
Green beans, gal/ton	20,000
Peaches and pears, gal/ton	5,300
Other fruits and vegetables, gal/ton	2,000-10,000
Chemical industries	
Ammonia, gal/ton	37,500
Carbon dioxide, gal/ton	24,500
Gasoline, gal/1,000 gal	7,000-34,000
Lactose, gal/ton	235,000
Sulfur, gal/ton	3,000
Food and beverage industries	
Beer, gal/1,000 gal	15,000
Bread, gal/ton	600-1,200
Meat packing, gal/ton live weight	5,000
Milk products, gal/ton	4,000-5,000
Whiskey, gal/1,000 gal	80,000
Pulp and paper	
Pulp, gal/ton	82,000-230,000
Paper, gal/ton	47,000
Textiles	
Bleaching, gal/ton cotton	72,000-96,000
Dyeing, gal/ton cotton	9,500-19,000

Source: Metcalf and Eddy, 1972. Page 32.

ECOSYSTEM FUNCTION

It is vitally important in regional strategies for water conservation to examine the hydrodynamic system(s) in the context of natural and/or man-modified ecosystems. The ultimate success or failure of water resource planning is shown in the function of ecosystems of which water is a vital part. The following paragraphs summarize the major categories of the goods, benefits, and services of ecosystem functions.

Production of Marketable Goods

This is one of the most obvious and direct benefits of ecosystem function. It includes all food materials, even though most of these materials are taken from highly modified and cultivated ecosystems. This category also includes all timber and natural fiber plants as well as nonrenewable minerals.

Genetic Potential for Crops and Domesticated Animals

This is a less direct benefit than marketable goods, but it is vitally important to human survival. All plants and animals used by man for food are evolutionary products of diverse ecosystems throughout the world. While the genetic stock of plants and animals now under domestication or cultivation is very large, it would be foolhardy to believe that no new, naturally occurring strains are needed to satisfy the world need for food in the face of potentially significant climate shifts in the years ahead. If climates do change, the need for new stocks may be very large indeed.

Building of Soils

Agricultural practices throughout the world have caused and continue to cause very high erosion rates in many areas. Since soils are the byproduct of natural and man-modified ecosystem events such as weathering, organic matter accumulation, and mineralization, it is vitally important that we not only protect existing soil reserves, but that we protect the processes which build new soils as well. There are obvious reasons why the protection of soils and soil building is important to natural and man-modified ecosystems.

Mineralization of Organic Residues

This service represents a vital link in the natural recycling of organic materials. In most instances the mineralization process also provides an important secondary benefit to growing plants; i.e., the intermediate breakdown products serve as soil conditioners and thereby enhance plant growth.

Natural Purification of Surface Water and Ground Water Resources

Most waterways serve significant water purification roles, but the waste loads they receive are usually not so high that the purification role overshadows all other roles. Sedimentation, decomposition of organic residues, and reaeration of water to replace the oxygen consumed by microorganisms in breaking down organic wastes are common to both "natural" and "designed" treatment. Natural purification proceeds constantly and quietly in most streams and waterways, and its benefits are sometimes not realized until disturbance slows the process or vastly increases the need for purification. Natural purification also takes place in marshes, local depressions which are periodically flooded, and other ground water recharge areas, thereby protecting ground water quality. One of the more insidious impacts of concentrated urbanization in a region is the vast change it brings in the quality and quantity of ground water recharge.

Attenuation of Air Pollutants

Vegetation in natural and man-modified ecosystems traps large quantities of air pollutants on leaves, stems, trunks, and branches. Local meteorological conditions, together with the type and density of vegetation, determine the effectiveness of this natural filtering function.

Modulation of the Hydrologic Cycle

Vegetation usually strongly modifies numerous processes in the hydrologic cycle. The kinetic energy of rainfall itself is attenuated, robbing it of force capable of loosening near-surface soil particles and initiating erosion. Roots penetrating the soil enhance ground water infiltration during and after storms, reducing runoff and enhancing natural stream recharge between rainfall events. Vegetation also prevents or greatly reduces the parching and hardening effects of direct solar radiation on the soil surface. Shading not only prevents excessive evaporative loss from the soil, but it also helps keep the soil surface in a more receptive condition so that rainfall can infiltrate the soil more effectively.

Amelioration of Near-Surface Climate Extremes

Vegetation prevents hot and dry extremes during summer and cold, desiccating extremes during winter. This amelioration has far-reaching effects on continued plant growth and development and on the development and sustenance of wildlife habitats.

Natural Control of Pest Populations

While ecosystem dynamics are not understood well enough in most cases to allow full understanding and control of pest populations by natural means, there is reason to believe that this form of control will become increasingly important in the future. Protecting large tracts of land and water which retain natural or near-natural conditions throughout all parts of the world may become one of the wisest investments from the standpoint of pest population control. To ignore the service that natural systems play in this respect and to assume that chemical and other artificial means will continue to be adequate in the future is naive.

Recreation and Aesthetic Enjoyment

Benefits of this sort vary greatly, of course, with vegetation, terrain, land use history, proximity of suitable land and water areas, climatic conditions, etc.

Study and Research

Almost any ecosystem offers some potential for ecological study and research, but in many cases the systems in greatest demand in this regard are those which have suffered the least disturbance from the natural condition.

CONCEPTUAL APPROACH

Our discussion so far has dealt with the hydrologic/ecologic setting in which water conservation measures must be identified. We are now prepared to establish a conceptual framework for water conservation planning.

Step 1: Hydrologic Inventory

In this step all water resources within the watershed or other study area in question are identified by type (pond, lake, canal, aquifer, reservoir, river, marsh, etc.), by size (surface area, volume, capacity), flow rates (inflow, outflow), turnover times (where appropriate), hydrologic linkages, watershed area, characteristics of storm frequency and intensity in the region, rates of diversion and/or consumption (including irrigation, export, recycle, etc.) and any plans or projects for hydrologic modifications.

Step 2: Hydrodynamic Modeling

For the present purpose, a model may be viewed simply as a reasonably complete concept of how elements of a system interact with each other. This does not preclude the use of computerized simulation models or other computer-assisted models, but it is beyond the scope of this paper to explore specific computer-assisted modeling. (One of many reasonable simulation approaches is described by D.G. Jamieson, 1975.)

Our task at hand is to organize the hydrologic and hydrodynamic facts about a given watershed in such a way that major connections are shown between water resource elements. A starting point may be the scheme shown in Figure 1. For a particular watershed it may be necessary to enumerate each principal inflow route, for example, including estimated total or relative average flow rates, each major storage element (lake, reservoir, lagoon), principal aquifers, and so forth. The level of detail developed in the modeling process must be consistent with the specific project objectives. For example, investigating regionwide opportunities for water conservation may initially require a much more general level of organization than a study designed to maximize recharge of a particular aquifer.

To the maximum extent possible, quantitative data should be incorporated into the hydrodynamic modeling process. For example, year-round estimates of water loss from a large reservoir through evapotranspiration in relation to such losses as outflow, diversion for irrigation, industry, and domestic consumption would generally be useful in identifying conservation opportunities.

Whenever possible, all significant transfer in the hydrodynamic system should be identified with respect to control parameters. For example, diversion of water from a river or lake for irrigation or industry is under complete manmade controls and generally well-monitored. Outflow from either a specific water body or the watershed itself may be under partial manmade control, or the control may be entirely natural, depending on hydrologic factors such as rainfall or channel gradient.

Step 3: Identification of Ecosystem Function

Having developed a fairly complete "hydrologic story," it is now necessary to examine the principal ecosystem function associated with land and water areas in the watershed. Rivers and larger streams may support a particular array of aquatic species with recreational and wildlife benefits; they may also assimilate partially treated wastewater discharges, recharge a set of shallow aquifers, and supply water for (or receive return flow from) irrigation systems. Creeks and small streams may serve slightly different functions. Land area within the watershed will invariably support a range of natural and man-modified ecosystem functions including agricultural production, support of residential, commercial, and industrial land uses, and recreational open space.

Step 4: Description of Land Use-Hydrologic Linkages

This step identifies land use impact on watershed hydrodynamics. The level of detail required for analysis depends on the specific objective. An exhaustive watershed study would show the land use or land uses of each basin and sub-basin within a watershed. It would identify the collection points, conveyance channels, and flow patterns for each drainage unit together with the land uses of that unit.

The impact of land use on hydrodynamics can be staggering. One study showed that urbanization accompanying a population density change from 100 to 13,000 persons/square mile caused a 10-fold increase in peak runoff rate, while the time to peak flow decreased 10-fold (Brater and Sherrill, 1975). The same study showed that "hydrologically significant impermeable area" increased linearly from approximately one percent at a population density of 1,000 persons/square mile to approximately 10 percent at a density of 7,500 persons/square mile. For a drainage area of 100 acres receiving 42 inches of rainfall, a change in runoff ratio from 10 percent to 50 percent leads to an increase in total annual runoff of over 456 million gallons. Such a change brings two hazards: it increases the probability of downstream flooding, and it diminishes ground water reserves on which stream base flow depends. Furthermore, conveying all or major portions of this runoff via storm sewers requires a large financial commitment and delivers runoff to receiving streams even faster than via surface drainage.

Figures 2 and 3 illustrate a schematic approach to the identification of land use-hydrodynamics linkages. The most effective form for collecting and analyzing this information may not necessarily be that shown here, but the conceptual approach is illustrated.

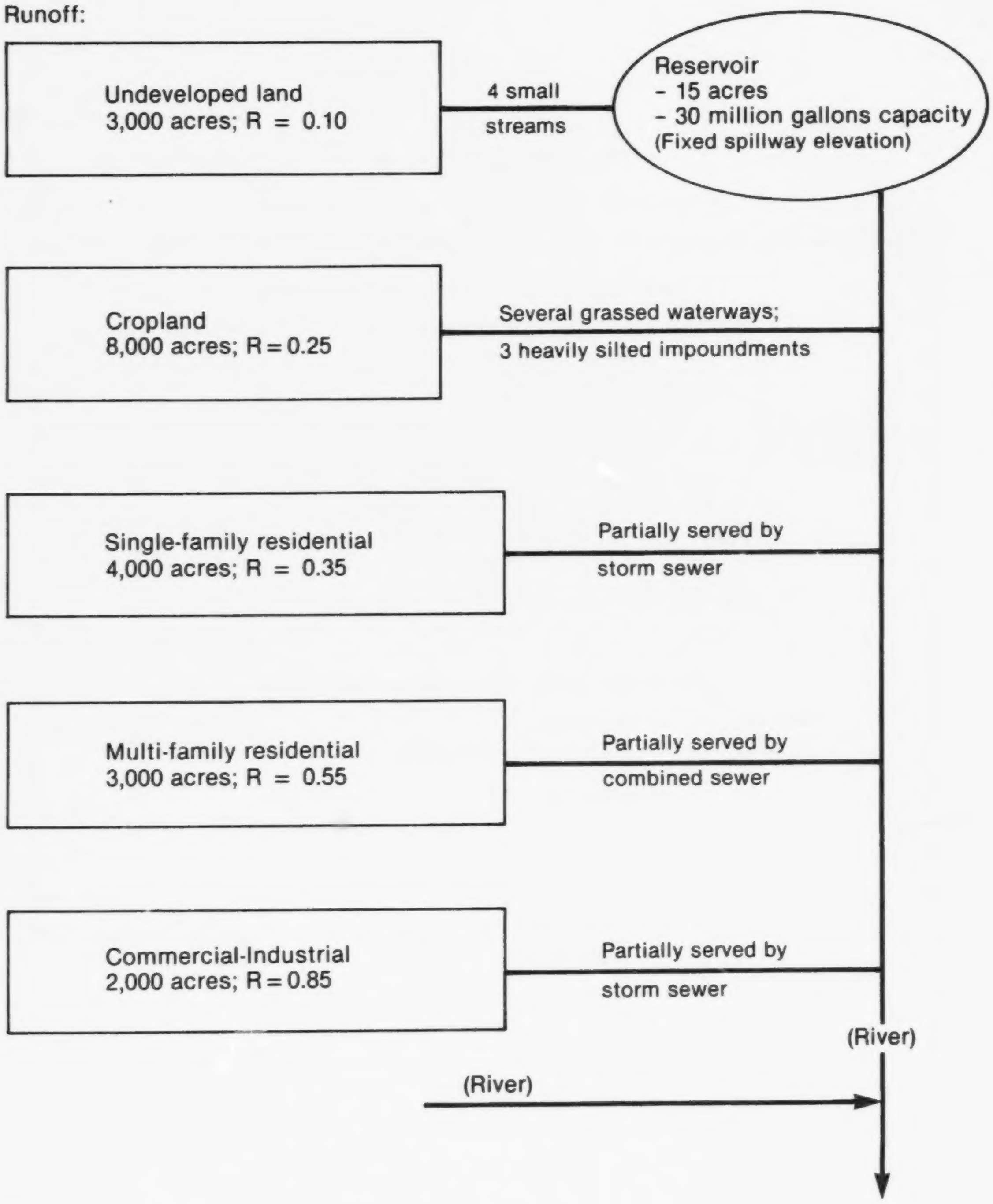
Step 5: Identification of Water Conservation Opportunities

This is the ultimate step, but one which must be taken repeatedly as development (and renewal) takes place.

The primary goal of water conservation in the present context is to minimize ground water withdrawals while maximizing the recharge of natrual ground water reserves. Ideally, there would be an ongoing attempt to monitor both the total withdrawal of water from a region and the effectiveness of recharge in relation to the total withdrawal. In some cases monitoring the water surface elevation of a crucial surface or ground water reserve could serve as a good indicator of this relationship. A regional hydrodynamic model would be particularly useful in determining which resources would best indicate the regional water balance.

a. Ground water recharge. One of the most important steps that can be taken at a regional level is the maintenance of flood plain areas as unpaved open space. There are many other benefits of such a policy, of course, but the infiltration capacity of these areas is vital to the replenishment of regional ground water. Depending on regional geology, there may be significant ground water recharge zones in areas well-removed from large rivers. These should also be identified and protected from uses which would decrease infiltration capacity.

b. Stormwater management. The stormwater sewer has become firmly entrenched in municipal engineering practice, and indeed it offers great convenience to those who live in and travel through built-up areas during and after storms. This convenience however, causes a major shift in the local hydrodynamic


Runoff:
Undeveloped land
3,000 acres; R = 0.10
4 small
streams
Reservoir
- 15 acres
- 30 million gallons capacity
(Fixed spillway elevation)
Cropland
8,000 acres; R = 0.25
Several grassed waterways;
3 heavily silted impoundments
Single-family residential
4,000 acres; R = 0.35
Partially served by
storm sewer
Multi-family residential
3,000 acres; R = 0.55
Partially served by
combined sewer
Commercial-Industrial
2,000 acres; R = 0.85
Partially served by
storm sewer
(River)
(River)

Note: R = Runoff coefficient

Figure 2. Hypothetical Land Use — Hydrodynamic Linkages (I).

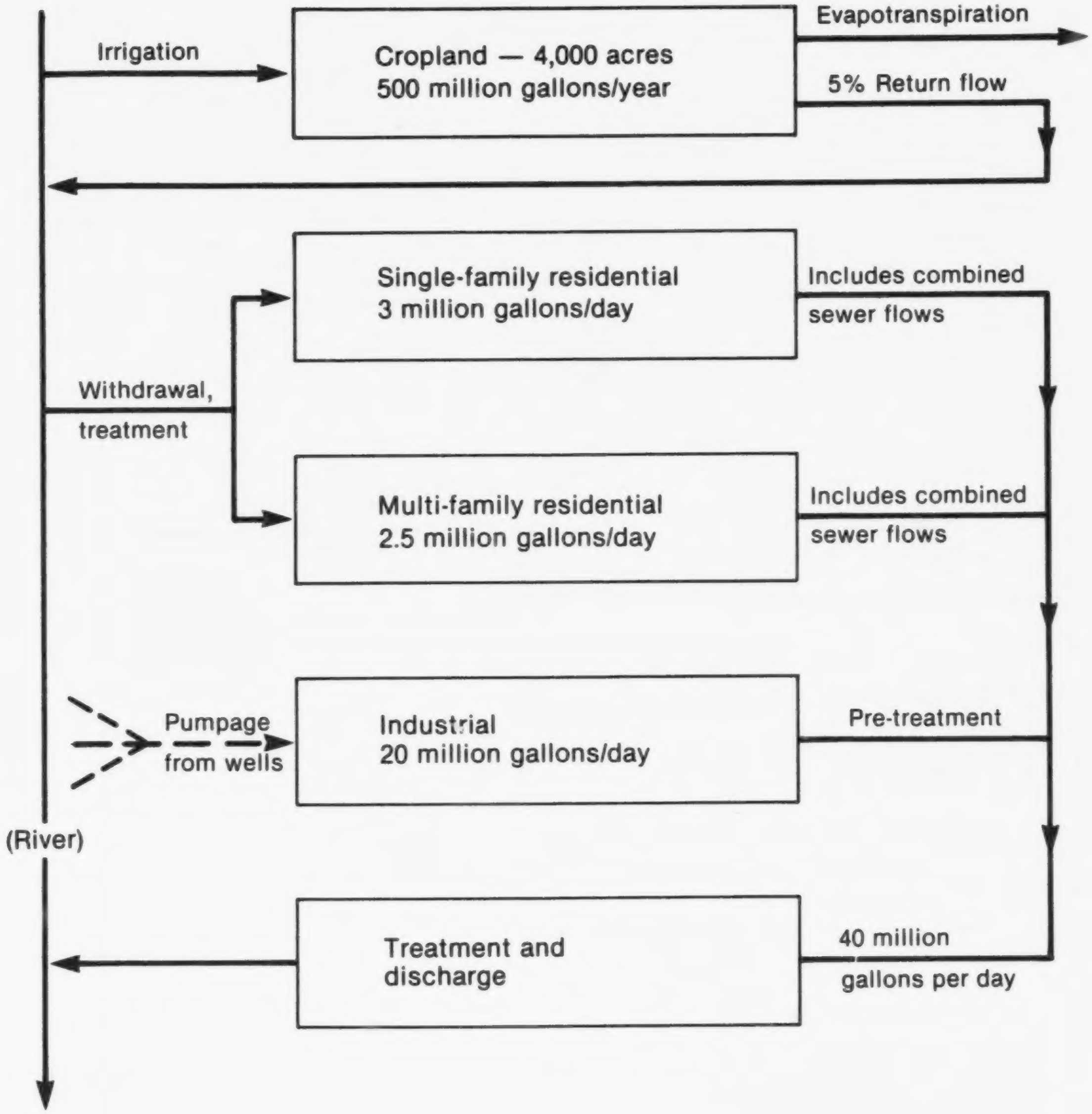

Irrigation
Cropland — 4,000 acres
500 million gallons/year
Evapotranspiration
5% Return flow
Single-family residential
3 million gallons/day
Includes combined
sewer flows
Withdrawal,
treatment
Multi-family residential
2.5 million gallons/day
Includes combined
sewer flows
Pumpage
from wells
Industrial
20 million gallons/day
Pre-treatment
(River)
Treatment and
discharge
40 million
gallons per day

Figure 3. Hypothetical Land Use — Hydrodynamic Linkages (II).

system. In particular, it rapidly transfers what would otherwise become ground water to the nearest channel or stream capable of bearing the expected flows. It may be quite possible in certain areas to use alternatives to the storm sewer. While each setting would require site-specific design and engineering, options worthy of consideration include rooftop retention, with gradual release to suitable land areas following storms; surface reservoirs, ponds, or tanks with similar release; subsurface structure or cavities which either discharge slowly by gravity or are pumped for discharge to suitable land areas; grass-covered swales or drainage channels with either slow natural release or controlled release; rock- or gravel-filled ditches, wells, or other cavities which receive runoff and gradually discharge to groundwater.

Another alternative involves the use of existing storm sewers to collect and convey stormwater from built-up areas and discharging flows to suitable land areas throughout the region instead of to streams and rivers. This could be designed either as an irrigation system or simply as a ground water recharge system.

c. Co-siting of land uses to enhance reuse. While opportunities of this sort are site-specific and usually require unique design, regional planning agencies should always be prepared to discuss such possibilities with water users. Industries requiring low-quality process water could be sited near residential stormwater outlets. Stormwater could be used as is or treated in settling basins and/or with swirl concentrators installed at the storm sewer outlet.

Another opportunity exists with food processing industries, which could be sited in the vicinity of cropland areas requiring irrigation. The quality of this wastewater may require little or no treatment prior to application.

Residential areas can be sited in such a way that cropland, pasture, or recreational open space could benefit from stormwater collected in the built-up area. Swirl concentrators could be used to treat the effluent if it were collected in storm sewers; settling basins could also be used to treat and hold water for irrigation.

Industrial activities generating large quantities of wastewater could be sited in the vicinity of mineral processing activities. Industrial wastewater with or without pretreatment could be used for washing, transporting, and sorting of materials.

d. Site design. This stage of any project development invariably presents many opportunities for water conservation. Under ideal conditions each site would be designed in such a way that all precipitation received on the site would be absorbed or retained there or conveyed to off-site resources through the hydrologic linkages which existed before development. Similarly, runoff or inflow received by the site should be accomodated by hydrologic linkages which existed before development. Furthermore, an ideal site design would require little or no irrigation to support improvement and/or protective plantings; i.e., prudent use would be made of precipitation received on the site or available to the site without freshwater withdrawal.

Specific elements of site design which should be considered include the preservation (to the maximum extent possible) of surface features which provide for conveyance and infiltration of surface water; the use of berms, swales, and grassed waterways to carry surface water in directions that lie in or close to natural contours; the use of porous pavements where hardstands are required; the use of percolation storage; the use of parking lot depressions with undersized outlets for detention and slow release; and the use of lakes and ponds with adequate overflow capacity to prevent excessive discharge during and after storms. Additional information on site design options which can be used to conserve water is available in numerous publications [Heaney, et al., (1975), Tourbier and Westmacott (1974), and Urban Land Institute, et al., (1975)].

EVALUATING THE WATER CONSERVATION OPPORTUNITIES

Having collected the information described in the preceding section, it will be possible to begin what should become an ongoing process: namely, an evaluation of water conservation opportunities. The detailed procedure used for this evaluation will, of course, vary considerably from one region to the next, but several basic criteria apply. These criteria are described below.

Conservation effectiveness

The basic questions here is simply, "How much water will be conserved by the proposed action?" This assumes that some baseline value of water use is available and that a quantitative estimate of savings can be made. In some cases the degree of accuracy of estimates may not be high, but the best estimate should be made as well as indication of estimate accuracy. It becomes the central argument.

Cost of Implementation

Again, some cases may arise in which the anticipated costs of a particular strategy may be long-term, secondary costs with relatively low accuracy. For example, the cost of excluding all further development in an aquifer recharge area may be difficult to assess. Due regard should be given both to primary and secondary cost factors.

Consistency with Existing Land Use Plans or Projections

Water conservation may not have been a major determining factor in pre-existing land use planning/projection efforts in many regions. For this reason, opportunities for land use adjustments to conserve water may or may not be consistent with pre-existing plans. For example, siting of food processing industries in the vicinity of cropland which requires irrigation may conflict with planned or projected uses of agricultural land. This conflict must be examined carefully in light of anticipated water conservation gains.

Maintenance Requirements

It is expected that certain water conservation opportunities will require ongoing maintenance. Linking industries capable of recycling process water may increase operation and maintenance costs for both or all industries concerned. If special treatment or holding is required, maintenance costs may be considerable and will require careful assessment in light of procurement cost and process effectiveness.

Environmental Effects

While many water conservation measures can have positive environmental effects, there may be negative impacts as well, including secondary impacts. Artificial ground water recharge, for example, may cause periodic high water tables locally and alter the habitat of native plant or animal species. Shallow aquifers may also be water-quality sensitive,and irrigation water may require greater treatment prior to irrigation of the overlying soil than first anticipated.

Aesthetics

In some ares the aesthetic considerations of conservation opportunities will be highly significant. Most site design adjustments to minimize or eliminate the need for storm sewers will require skillful design work. The use of surface features to convey and store water presents significant aesthetic opportunities and hazards.

SUMMARY AND CONCLUSIONS

Conserving water on a regional scale through prudent land use planning requires the ongoing cooperation of landowners, hydrologists, planners, engineers, ecologists, landscape architects, and public officials. A successful strategy for conservation should have simple, widely accepted goals;

a system for collecting, analyzing, and updating regional hydrodynamic information; an ongoing procedure for assessing the impact of regional land use on water consumption and regional hydrodynamics; an ongoing search for ecologically sound water conservation opportunities which arise whenever land use changes are proposed; and an ongoing procedure for analyzing the effectiveness of actions taken to conserve water.

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An Equitable Rate Structure's Relation to Conservation and Wastewater Flow Reduction

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The Fairfax County Water Authority provides wholesale and retail water service to approximately 640,000 persons residing in the Northern Virginia suburbs of Washington, D.C.

In 1974, the Water Authority's financial requirements dictated an increase in revenues. Concurrent with these revenue needs it was felt that a new public attitude regarding utility rates was evolving and required an entirely new approach to the methodology of establishing a schedule of rates, fees, and charges for water service. Until 1974, the descending block scale was the standard retail billing method used. In establishing a new rate methodology, the Authority wanted a rate structure that was equitable to all customers, with water conservation being a secondary consideration.

Recognizing that perfect equity is not possible without individual rates for each customer, the Authority felt that certain practical improvements to traditional and historic rate schedules were possible by addressing marginal costs on a more refined basis.

The Authority recognized the principal that economic efficiency of a water utility is more nearly related to uniformity of use, rather than the quantity of water used. Therefore, it was not considered fair for all customers to pay for plant capacity that is required by a relatively few customers who use a disproportionately greater amount of water in the summer peak-use season.

From a conservation viewpoint, the amount of land to be flooded for water supply impoundments is determined by the seasonal high water demand and the low flow of the tributaries into the water source. Any reduction in the seasonal high water demand would make it possible to reduce the size of impoundments, thereby reducing costs and water rates. The Authority wanted to address the aforementioned in a practical manner with its quarterly cycle billing system without employing expensive demand meters or telephonic readouts.

In searching for an effective rate structure that would properly address the matter, the Authority considered but rejected the ascending block scale, winter-summer differential, and year-round billing charge based on peak season quarterly use. The ascending block scale is punitive to large users, regardless of their efficiency, and spreads the allocation of costs to all users, therefore minimizing the impact on the relatively few customers who create the added peak demand. This is especially true if this rate is applied year-round rather than seasonally. The winter-summer differential has basically the same faults in that it does not necessarily target in on peak users, creates cash flow problems, and engenders customer dissatisfaction. This schedule is more of a problem if the differential is significant, yet, if the differential is small, the peak season impact is minimal. A year-round billing charge based on peak season quarterly use is not practical, even though it has an economic logic and addresses the customer on an individual basis during the peak-demand season. In a quarterly cycle billing system in which there are various peak season months, it is not possible to forecast the quarter in which the demand peak will occur and fairly apply the peak quarter to all customers. This and other administrative and equity problems eliminated this system of billing from consideration.

The Authority is the billing agent for the sewer service charges imposed by the governing jurisdiction in the retail water service area. The annual sewer charge is based on winter quarter water consumption; that is, a customer's sewer bill will not exceed his winter quarter bill during the remaining three quarters of the year. Based on this billing system the Authority investigated the use of a peak-use and/or marginal cost rate for water.

Using very good historical records, the Authority was able to obtain the average water consumption for the winter and summer quarters by customer class (e.g., single family, townhouse, commercial, etc.).

Considered first, but rejected, was a peak-use charge for peak-season use over and above winter quarter consumption by customer class. For example, if the average single-family residential customer used 21,000 gallons during the winter, then a peak-use charge would be assessed to all water used in excess of 21,000 gallons during the two peak summer quarters for all single-family residential customers. This method was rejected because it was determined that a definite inequity favoring the smaller consumer over the larger consumer existed even though the latter may utilize water more efficiently.

With further investigation, the Authority was able to ascertain from historical records that the average peak quarter use exceeded winter quarter consumption by 30 percent for all customer classes. The Authority proposed the assessment of a peak-use charge over and above the general commodity rate for those customers whose consumption in the two summer quarters exceeded 1.3 times their winter consumption, based on the logical assumption that those customers who consume water at a disproportionately higher rate in the summer quarters as contrasted to the winter quarter are generally the same customers who create the peak demands. This method was later modified to include an allowance of 6,000 gallons plus winter quarter consumption, or 1.3 times winter quarter consumption, whichever is greater. This later modification was implemented because a disproportionate number of small users were affected, for obvious reasons. This modification has balanced the application of the method between large and small users.

When the Authority hypothetically compared the peak-use schedule to the aforementioned conservation schedule to achieve year-round water and wastewater flow reduction, it assumed that under normal circumstances the maximum rate that the public would tolerate would produce a reduction elasticity of approximately five percent in total annual water sales. The year-round rate schedule would have a resultant reduction effect of roughly six percent relative to water plant and reservoir capacity versus an anticipated 12 and seven percent respectively for the peak-use schedule. This type of rate schedule, as opposed to the peak-use schedule, would have a greater effect on reducing wastewater flow but probably far less than five percent, depending upon the infiltration ratio of the sewer system. Our winter quarter sewer billing system addresses this conservation potential, and we have noticed a slight winter quarter reduction.

Further, we are fortunate in that our neighbor in Maryland, the Washington Suburban Sanitary Commission, has a year-round conservation rate consisting of an ascending block scale initiated in 1977. In the future we should be able to present meaningful comparative statistics on the equity-oriented schedule versus the conservation-oriented schedule.

Now that the basic peak-use charge methodology had been determined, the Authority had to establish a fair peak-use surcharge. Again using historical data, the Authority determined that the basic facilities must be designed and built to meet a maximum daily demand of 1.6 times the average daily demand. Because of the hypothesis that the peak user created the need for the excess plant capacity had been asserted, the differential in annual capital cost between 1.3 times average daily winter consumption and 1.6 times the average daily consumption was established for the peak-use charge. Extensive customer sampling showed that approximately eight percent of the total amount of retail water sold was included in the peak-use category. Without any historical data to determine the probable effect of this surcharge on reducing peak consumption (elasticity), the Authority estimated that a 50 percent reduction might occur, this reducing to four percent the amount of water sold at the peak-use rate. The charge was then determined by dividing the annual cost of the excess retail plant capacity by four percent of the total amount of retail water sold, as shown below.

$$\frac{\frac{1.6 - 1.3}{1.6} \text{ x Annual Capital Cost (dollars)}}{4\% \text{ x Annual Water Sales (1,000 gallons)}} = \text{Peak Use Rate \$/1,000 gallons}$$

This resulted in a peak-use charge of $2.45/1,000 gallons. To maintain the same total annual revenue from retail sales, a previously derived basic commodity charge was reduced from $0.81/1,000 gallons to $0.70/1,000 gallons.

The Authority's peak-use charge has received acceptance among our customers, primarily for the following reasons:

- It economically encourages water conservation during the peak season when water supplies are most vulnerable
- It is a fair and equitable rate
- It is not punitive
- It has an economic basis
- It affects only the one-fourth of our customers who create the demand
- It offers individual customers the proper economic choices
- Customers that minimize winter consumption yet do not exceed their peak period allowance can maintain a very economical annual water and sewer cost

Since the adoption of a peak-use charge in 1974, there has been a 25 percent reduction in the number of customers exceeding the peak-use allowance. Certain summer season water users who are directly impacted by this rate system, such as those who have swimming pools, plant nurseries, and golf courses, have come to accept the reasonableness of the rate schedule. These peak season water-intensive customers realize that by interfacing their water bills with the sewer billing they obtain an equitable rate which results in very nearly the same annual costs as compared with a fixed, year-round water and sewer rate.

The application of the Authority's rate system has been economically successful relative to anticipated revenues. From the plant capacity and conservation aspect, although it is too early to draw definite conclusions, all indications have been encouraging. Since the summer of 1974, the Authority has not experienced a peak-day demand of 1.6 times average (Table 1). In 1976, the peak-day production was 1.4 times the average with approximately the same precipitation in May and June of 1976 as in June and July of 1974, when the peak day was 1.63 times average. To date, 4.5 percent of the water sales have been at the peak-use rate, and the Authority has experienced approximately a five percent reduction in total annual sales. Assuming a 10 percent system loss allowance, the rates have been responsible for reducing total annual production by 4.6 percent. This five percent sales reduction represents a potential 12.5 percent reduction in plant size. From a conservation viewpoint, the five percent reduction of total annual water sales, if maintained, can safely be converted to a seven percent reduction in peak-season reservoir requirement.

Except for the winter quarter sewer billing, the Authority's rate system, as predicted, has only a minor effect on the reduction of wastewater or sewage flow. The primary area of elasticity for peak-use reduction in the Authority's geographical location with predominantly residential customers is lawn irrigation, which has no effect on wastewater.

TABLE 1. PEAK-USE CHARGE ANNUAL SUPPLY AND SALES COMPARISON

Year	Precipitation (inches) May	June	July	August	Average day demand (mgd)	Maximum day demand (mgd)	Ratio of maximum day to average day
1973	4.78	2.11	2.63	4.41	56.22	84.0	1.49
1974	4.37	5.40	1.26	5.77	57.62	94.2	1.63
1975	4.71	2.15	7.16	3.54	57.45	85.3	1.48
1976	3.57	1.21	4.54	2.13	63.87	89.6	1.40
1977	1.73	3.28	4.05	4.81	64.19	90.5	1.40
1978*	5.13	2.79	4.28	5.85	64.78	86.2	1.33

* Through August 1978.

In conclusion, it is suggested that water suppliers in the mid-Atlantic States and other areas with a humid climate, high sewer infiltration problem, and seasonal extremes not overestimate the potential of rate structures relative to water and wastewater demand reductions. Unless a community is ready to live with unrealistically high and probably unjustifiable water and sewer rates, it will be working on approximately a five percent elasticity factor for total annual demand. The Fairfax County Water Authority feels it has utilized the rate structure that maximizes the economical and conservation potential of this elasticity by concentrating on the peak-use season.

We are satisfied the Authority has adopted the best rate system for the geographical, climatic, educational, economical, and political conditions of our area. If you are so satisfied, you probably have the right rate method for your area.

Water Resource Management: Marin County, California

J. Dietrich Stroeh
General Manager
Marin Municipal Water District

About eight or ten years ago the Marin Municipal Water District became involved in water resource management by necessity: our water supply was simply insufficient to meet our water demand. Successive bond issues for the development of new water sources were placed before the voters...and successively failed. It became necessary to impose a moratorium on new water connections and it was evident that our consumers--for political, environmental, or other reasons--were demanding and expecting a new approach to the development of water supplies.

Our District is both blessed and damned by its unique location. For those of you unfamiliar with us, Marin County anchors the northerly end of the Golden Gate Bridge. We are bounded on the east by San Francisco Bay, on the west by the Pacific Ocean, and on the north by northern California. We are blessed with a nearly ideal environment, one which has caused us to become one of the major bedroom communities for the San Francisco metropolitan area. Our District, which comprises most of the county, has a population of approximately 170,000, served through some 51,000 active service connections. This location, with its spectacular views across San Francisco Bay is, however, physically separated from the mainland of California, making it extremely difficult and expensive to tap the tremendous aqueducts delivering water supplies to central and southern California. Excepting a limited connection to the Russian River Basin, our water supplies are all developed incounty, which resulted in Marin County being one of the first and one of the hardest hit during the recent drought.

These conditions caused us to develop what we call our Water Supply Management Program, integrating three basic elements. The first element is an additional incounty reservoir, now under construction and expected to be on-line in 1979. Significantly, this reservoir was sized to reflect water savings to be obtained through the other two elements of our program, wastewater reclamation and conservation.

Second, two wastewater reclamation facilities are now in the advanced planning stage. These will treat effluent to a quality acceptable for landscape irrigation and, when placed on-line next year, this reclaimed water will "replace" potable water now being used for such irrigation.

The third element of our Management Program is water conservation. Our program takes two thrusts, the first being mechanical control of future construction. Through State legislation and local building codes we control, to a great extent, future water use by designating the type of fixture or appliance to be installed in any new construction, modification, or alteration. A good example of savings to be obtained is replacement of the standard flush toilet--which uses about five gallons of water per flush cycle--with water-saver toilets, now available in a variety of colors, designs, and prices, designed to use approximately 3-1/2 gallons per flush cycle. Using available statistics on water use, we discover that this savings alone, 1-1/2 gallons per flush, will save the average family approximately 900 gallons of water per month, or 10,000 gallons per year. You can see that should projected growth indicate the addition of, say, 10,000 residential service connections in a community over some planning period, then requiring the installation of this water-saving fixture in those 10,000 units should save approximately 300,000 gallons of water a day at the end of the planning period. The chief point here is that water consumption of that future population can, at least to some extent, be mechanically controlled.

But what can we do today? This brings me to the second thrust of our water conservation program, the retrofitting of existing consumers. At Marin Municipal we chose to recognize retrofit devices as part of our water supply effort and to pay for those devices out of District funds. This simply means that we chose to furnish the devices free of charge to our consumers. We developed a water-saving kit, then selected a highly identifiable neighborhood, and distributed the kits on a door-to-door basis within that neighborhood while simultaneously publicizing this effort in offering the kits to any District consumer who requested one. It may be noted that no significant problems arose from the door-to-door distribution, and one interesting result is that we received approximately 70 percent participation.

We used billing inserts to furnish our consumers with information on where devices could be obtained, together with helpful hints on repair of leaky faucets, good irrigation practice, and so on. Our key slogan was "Save Water, Save Money."

During our first year of drought, the winter of 1976-77, we discontinued the door-to-door distribution, and found that it was not necessary. Many consumers--about a 40 percent response--came to the District offices to pick up devices. Through the cooperation of other local agencies and local businesses, devices were made available at real estate offices, chamber of commerce offices, shopping center malls, fire stations, etc. We were surprised to discover that during the first week of 1977, when the drought was really being felt and we were initiating our first rationing programs, we were visited daily by some 2,000 consumers to obtain these devices.

The result of this effort is summed up in a State of California, Department of Water Resources survey which indicates that approximately 89 percent of our consumers obtained and used our devices. The survey further shows that 50 percent used the low-flow showerheads that we provided, about 22 percent used a shower flow restrictor, and an astonishing 93 percent of our consumers used the toilet tank displacement bottles.

The state's survey also determined the attitude of our consumers toward conservation in general.

- Residential Consumers. Their attitude was positive, a community-spirited effort. We obtained an actual reduction in water use of about 65 percent from normal (our goal was a 57 percent reduction). The visible result was brown lawns throughout the county, dirty cars and sidewalks, and neighbors turning each other in for irrigation violations. There were neighborhood block parties with prizes for the lowest consumption. There were BYOW parties--meaning "bring your own water."

- Non-Residential Consumers. Unlike our residential users, our commercial and light-industrial consumers did not respond so well to voluntary conservation and it required rationing regulations, due to the drought, to gain their initial response. I hasten to add, however, that demonstrations of mechanical methods for conservation were very well received, particularly when they demonstrated cost savings to be obtained. For example, we worked with the staff of San Quentin State Prison and reduced their consumption from approximately 1 million gpd to approximately 300,000 gpd, a substantial amount of water and a substantial cost savings to the State. Many commercial users installed air-cooled compressors for refrigeration and recycled the cooling water used in other plant processes. Drip irrigation systems were installed throughout the county and nurseries began inventorying and selling drought-resistant plants.

Generally, we discovered that the public simply does not understand very much about the water industry: where water comes from, how it is processed, or the magnitude of the service provided. Our rationing restrictions and conservation helped to create an atmosphere wherein our staff was welcomed to speak before school groups, service clubs, etc. These talks aided considerably in the "public education" of the water industry, so necessary to gain full cooperation of the public in any conservation effort. We discovered one major difficulty: many, many persons believed that with less water being used, the cost of water should go down. This simply is not true; in fact, just the opposite happened. Our normal work continued to be performed and, in fact, increased due to the need of "having our own house in order" to avoid criticism. Our overtime increased dramatically as we repaired small leaks at night or on weekends, leaks which ordinarily would have been repaired during normal working hours. It was necessary to add staff to our switchboard to accommodate the hundreds of questions asked daily by our consumers relating to violations, leaks, and items of that nature.

Certain details relating to the cost of our conservation and rationing effort may also be of interest to you.

- Billing Inserts. These gain a high response at a fairly low cost. They can easily be changed for each billing cycle, gaining a flexibility for seasonal adjustments. They cost us $.03 to $.05 each.
- Gutter Flooder. This is our name for an ordinance which prohibited the running of water to waste. It is low in cost and almost self-policing in that neighbors complain when they see a "gutter flooder." It also gives the water agency a legal means of responding to water wasters, either through fines or terminating water service.
- Drought-Tolerant Garden. A demonstration garden can be an effective educational tool. The garden shows drought-tolerant plants and a list of such plants should be available to visitors. We created ours in cooperation with the Marin County Parks and Recreation Department, who donated use of the land and assisted in the selection of plants. The cost was relatively low.
- Television, Radio and Press. The cost of producing a meaningful television release is simply prohibitive at approximately $1,000 per minute. The radio industry did cooperate with public service announcements, many of which were taped by our own staff. Newspapers cooperated well, with entire pages devoted to methods of water conservation.
- Civic Functions. We found our participation in parades, fairs, and other civic functions of this type to be low-cost, helpful in gaining community involvement, and useful in implementing the conservation ethic.
- Inverse "Ascending" Water Rates. This can be an effective means of conservation if their use is not considered to be a "penalty," and if the rate, through classification of users, is not prejudicial to certain consumers.

And finally, while it is evident that our water conservation programs were propelled by the drought and its rationing restrictions, it is interesting to note that our consumers have not abandoned their conservation efforts and our consumption, now that the drought is over, is approximately 75 percent of normal. The "conservation ethic" that was developed through the drought is now well established and I believe it imperative that we continue a public relations program in order to maintain this ethic.

It has been my pleasure to share our experiences with you and I sincerely hope that I have stimulated you to consider water conservation as a vital part of your own program for total natural resource management.

Elmhurst Water Conservation Program

Neil R. Fulton
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The Elmhurst (Illinois) Water Conservation Program, which was developed over the last three to four years, was an attempt by local government to conserve natural resources. Elmhurst asked the questions: can per capita water consumption be reduced? What part should a municipality play in a water conservation program? And what are the benefits of such a program?

You might ask why I'm describing the Elmhurst Water Conservation Program, since as Chief of the Bureau of Resource Management of the Division of Water Resources, Illinois Department of Transportation, my connection to the program is not very obvious. Prior to my starting work with the State, I spent eight years with the City of Elmhurst. The last four of these years were as Assistant City Manager. It was during this time period that the Water Conservation Program was developed and therefore, I am quite familiar with the topic.

Elmhurst water conservation activities included a public information program, rate changes to reduce usage, plumbing code amendments requiring water-efficient appliances, control on outdoor use of water, and free distribution of displacement dams to lessen water used in toilet flushing.

Elmhurst is a mature community of approximately 45,000 located in eastern DuPage County, fifteen miles west of Chicago. While Elmhurst is primarily a residential community, it serves a major hospital, a private college, and industrial development.

Elmhurst owns and operates its own water supply and wastewater treatment systems. Elmhurst's water supply primarily comes from deep wells drilled in the Ironton Galesville sandstone formation. Pumpage from this sandstone formation has exceeded the rate of recharge since 1957, and the water level in Elmhurst's deep wells has been declining at an average rate of fourteen feet per year since 1960.

Prior to the water conservation program, projections showed that if these trends continued, pumpage from the aquifer would have to be significantly reduced by 1985.

As a result of the declining water table, Elmhurst and other communities in DuPage County have been seeking an allocation of Lake Michigan water since the mid 1950's. In 1977, the Division of Water Resources of the Illinois Department of Transportation granted Elmhurst an allocation of Lake Michigan water. The allocation permit requires that Elmhurst utilize a number of water conservation techniques. The United States Supreme Court decree that controls the withdrawals from Lake Michigan by the State of Illinois and its political subdivisions also requires that all practical means be used to conserve water in the northeastern metropolitan regions of Illinois.

Elmhurst's sewage treatment plant has a dry weather hydraulic capacity of six million gallons per day(mgd). At the start of the water conservation program, the treatment plant was close to its hydraulic capacity. Plant capacity would have to be increased or sewage flows decreased to allow any new connections to the sewage collection system.

This situation, coupled with the desire to develop programs that would conserve important natural resources and protect them for future generations, motivated Elmhurst to develop a comprehensive water conservation program.

Elmhurst's program had the goals of reducing water consumption by 10 to 15 percent and sewage treatment plant hydraulic loads by 8 to 10 percent. The city's average daily water consumption is approximately 5.3 mgd. A 10 percent reduction in this figure would daily save approximately 530,000 gallons of water and a 15 percent reduction would save approximately 795,000 gallons.

In addition to lowering average daily consumption, the water conservation program was developed to reduce the ratio of both maximum-day and peak-hour consumption to average daily consumption. A successful water program would make unnecessary a planned $400,000 deep well for additional short-range supply and for peaking capacity.

Reducing flows to the sewage treatment plant by 8 percent would be equivalent to 400,000 gallons per day (gpd) and have a population usage equivalent of 4800 people. A successful water conservation program would thus also allow expansion of the sewage collection system to serve new construction.

The most important single portion of the water conservation program may have been public education. Elmhurst's experience has been that once its residents are made aware of a problem, they will work hard to help solve it. The public education program included a water bill mailing insert that explained the necessity for conservation, and a newsletter sent to all residents that described the water supply problem, suggested methods to conserve water, and explained the conservation program.

Local newspapers and a local radio station provided excellent coverage of the water supply problem and water conservation program.

This multimedia blitz made most residents aware of the water supply and sewage treatment problems. Elmhurst's program also received television news coverage from two Chicago network stations.

Until 1975, Elmhurst used a declining block rate structure for water and sewer service; the unit charge decreased as consumption increased. The historical basis for this type of rate structure is load spreading, and it is most applicable in systems where the peak demand of large users occurs at times of low demand for normal users. This structure tends to reward the large water user.

In reviewing various water rate philosophies, Elmhurst decided that the most equitable rate structure for a primarily residential community was a uniform unit charge, independent of consumption volume. In late 1975, Elmhurst changed from a declining block rate to a uniform unit charge for water and sewer service.

In late 1976, Elmhurst made another change and instituted an excess facilities water rate. This rate was based upon a study of the ratio of summer demand to winter demand for the average user. The study found that a small percentage of users were responsible for the high summer water demands. Since a water system must be designed for peak hour and maximum daily consumption--which occurs in the summer--as well as average daily consumption, the water system is underused in the winter.

It seemed equitable to distribute the cost of the excess facilities (supply and storage capacity) to the users who were responsible for increased summer demands. The excess facilities rate established a base consumption for a three-month period during the winter. Water used during summer billing periods that exceeds base consumption by 30 percent or 600 cubic feet, whichever is larger, is charged at a higher rate. Elmhurst feels that the excess facilities rate better relates charges for water to the cost of production and also provides an incentive for water conservation. The excess facilities rate is 2.67 times the base rate.

Two big users of water inside the home are flushing toilets and washing and bathing. It has been estimated that 41 percent of residential water consumption is utilitzed for toilet flushing and 30 percent for washing and bathing.

The typical toilet uses approximately five to seven gallons of water for a single flush. Newly designed water-conserving toilets use only 3.5 gallons of water. The use of water-conserving toilets represents a 30 to 40 percent reduction in water use for toilet flushing and a 12 to 16 percent reduction in total household consumption for an average family of four.

The ordinary shower head uses approximately six to 12 gallons per minute (gpm). Newly designed water-conserving shower heads use approximately two to three gpm and are just as effective. This represents a 50 to 70 percent reduction in shower water consumption. The installation of a shower head shut-off, which is a simple quarter-turn valve just upstream of the shower head, can also reduce water used for showering. This device allows the water to be shut off while soaping up during a shower. The use of low-flow shower heads and shut-offs not only conserves water, but also conserves energy because of a reduction in hot water usage.

Elmhurst modified its plumbing code to require that all new plumbing installations and replacement plumbing fixtures comply with the following maximum standards:

- Toilets, tank-type: 3.5 gallons per flush
- Toilets, flush-o-meter: three gallons per flush
- Urinal, tank-type: three gallons per flush
- Urinal, flush-o-meter: three gallons per flush
- Shower heads: four gpm maximum
- Lavatory sink faucets: four gpm maximum flow with both hot and cold water supply fully open.

Elmhurst's plumbing code changes will have the long-term effect of reducing total water consumption; however, because Elmhurst is a mature community, the immediate effect would be small. Since Elmhurst had a short-term water reduction goal, a program was developed to retrofit existing toilets and shower heads with devices that would cut consumption. Field tests have established that conventional toilets can be retrofitted with volume-reducing or flush-control devices which may reduce water consumption by up to 2.5 gallons per flush.

The flush volume is reduced by placing plastic bottles, displacement dams, or other devices in the flush tank to displace or reduce water volume while still maintaining the same static head and initial velocity of water into the toilet bowl.

While not all toilets can be retrofitted with these decives, it is estimated that an average 1.6 gallons of water can be saved per flush with the installation of displacement dams.

To reduce shower head flow, a small orifice or flow-control device can be placed just upstream of the head and reduce usage to two to four gpm, depending on system pressure and orifice size.

Elmhurst decided that a retrofit program was necessary if significant amounts of water were to be saved quickly. Retrofit was done in conjunction with the public education program. The city council passed a resolution requiring that all toilets, where technically feasible, be retrofitted with displacement dams by January 1, 1978.

In July, August, and September of 1977, the city delivered to each home a set of displacement dams. Where the resident was at home. an offer was made to install the dams. Where individuals were not at home, the displacement dams were hung in a plastic bag on the door knob with a letter of introduction from the mayor, instructions on how to install the device, plus a postage-paid post card to request installation assistance.

In addition to the displacement dams, each residence received a set of orifices for shower heads, and dye tablets to check for toilet flush tank leakage. The program was successful and cooperation was obtained from nearly every resident.

Elmhurst residents can use water for outside purposes from 8 p.m. to 8 a.m. three times a week per home. This is controlled by allowing the homes with even street numbers to sprinkle on Monday, Wednesday, and Friday, and the odd-numbered homes, on Tuesday, Thursday, and Saturday. This program was designed to regulate the peak demand for lawn sprinkling so it will not conflict with peak demand for interior uses.

In meetings with landscape architects and others involved in maintaining exterior landscaping, it was found that lawn watering was not necessary in the Chicago metropolitan area because rain water is adequate to maintain established lawns if they are properly fed and mowed. Residents of the community were encouraged not to water their lawns unless they were newly seeded or sodded. Information was provided to residents, by newsletter, on the proper method of lawn maintenance, including application of fertilizers and mowing techniques.

Recognizing that not all residents would be willing to stop watering their lawns, proper techniques of watering were also described. This included sprinkling in the morning hours, just prior to sunrise, when the evaporation and evapotranspiration would be reduced, and also that the watering be done slowly, deeply, and infrequently to insure adequate penetration and reduce runoff.

The Elmhurst Water Conservation Program costs approximately $45,000 or $1 per capita. This cost includes purchase of displacement dams, and the labor necessary for their delivery and installation, as well as the public education program.

It is too early to determine the ultimate results of Elmhurst's Water Conservation Program. Some preliminary results are that peak day consumption in 1977 was 30 percent less than in 1976, and 1977 average day consumption was 6 percent less than 1976. Although information for 1978 is not available, preliminary projections indicate that similar savings will occur. Elmhurst also saved the construction cost of a peaking well estimated at approximately $400,000.

In order to determine the success of the Elmhurst Water Conservation Program, water use will have to be monitored over the next few years. It is important to determine if there has been a change in the historic pattern of increasing per capita consumption. These values have traditionally been used for projecting future water demand; however, the goal of the Elmhurst Porgram and our hope is that the traditional pattern can be reversed and per capita consumption either will be held constant or reduced.

Water conservation is not a one-time program. Elmhurst is now reviewing the possibility of a revised billing format which would involve a change from a post card to a narrative bill. The narrative bill would allow for better communication with water users and bill payers. Additionally, parts of the public education program will have to be continued so that residents of the community will be kept aware of the need for water conservation and methods of accomplishing conservation.

An important part of the Elmhurst Water Conservation Program was commitment by community leaders to the development of a conservation ethic. This occurred because the community leaders believed in water conservation. I think something similar could be said for the attendees at this conference. If you and I do not believe in water conservation and perhaps more importantly, conservation as a way of life, then this conference has not been a success. If we do believe in a conservation ethic and the necessity for careful management of all our natural resources with the understanding that our resources are limited and not disposable, then at this conference we have learned ways to put that belief in action. It is only through this type of commitment that we will be able to sell conservation as a way of life and see changes in national habits that are so important to the future of this country.

Water Resources Management in New York State

William W. Horne
New York State Department of Environmental Conservation

Between Albany, New York, and Chicago lie numerous lakes, magnificent rivers, and a myriad of small ponds and streams--perhaps one of the greatest freshwater resources in the world; and yet, those who are responsible for developing water resources in this area of seeming plenty know that the management of water presents one of the highest priority problems faced by the States in the Northeast and Midwest. This is a vast area with an appearance of plenty, but, in fact, an area where water is rarely available at the time and place needed in sufficient quantity and quality to supply the demand.

Water has always been a high priority to the State of New York. I would like to briefly outline the history of the State in water resources management, describe today's water management needs, and then devote the bulk of this address to a discussion of current policy interests and how we visualize the developing legislation and subsequent programs at various levels of government.

The State of New York gave early attention to water resources through construction of the Erie Canal, begun in 1817, which was the State's first significant enterprise in water resources development. That canal played a major role in the growth of the Western United States. In fact, a United States Senate committee reported that it did more to advance the wealth, population, and enterprise of the Western States than all other causes combined. This wasn't a one-sided advantage because our industry, much of if water-dependent, grew and prospered.

Thus, for the first hundred years following the Revolution, New York State developed, supported by an abundance of water suitable for the demand generated.

The creation of State water management institutions did not begin until the end of the 19th century when New York experienced widespread flooding which led to creation, in 1902, of the Water Storage Commission, the State's first agency for regulation of streams and water storage.

At about the same time, the rapid growth of New York City brought ever-expanding demands for the development of new water supplies. These demands were met over the years by State legislative actions supporting the city's development of a system recently estimated to be worth some $16 billion.

Other communities in the State managed to develop their water supply systems with a minimum of State participation, although a Water Supply Commission was created in 1905 to assuage the fears of small communities that New York City would condemn land for public use without regard for the communities' water needs.

By 1911, State activity had been concentrated in a Conservation Commission with a broad range of water resources responsibilities. In 1926, that Commission was supplanted by a Conservation Department which, in 1970, evolved into the current water resources management agency, the Department of Environmental Conservation. The Department combined the air, water pollution control, and solid wastes programs of the Department of Health; the forest management, fish and wildlife, conservation education, and water resources programs of the Conservation Department; and the pesticide control program of the Department of Agriculture and Markets. Subsequent program and bond issue legislation has provided the sinew to make this Department into a comprehensive environmental and resource management agency.

Water planning has kept pace with program development by providing the policy guidance for legislation and implementation.

- In 1962, the State financed a comprehensive sewage study program to develop area-wide sewage utility master plans for counties and smaller service units. These studies, followed by detailed facilities' planning, have provided the basic planning for the State's Pure Waters Program which will expend nearly nine billion dollars for sewage treatment facilities by the time the authorizations are exhausted. A one billion-dollar State Pure Water Bond Act provided construction funds for the early stages of the program.

- The State has financed water supply studies for counties. These studies concentrated on public municipal and industrial water supply needs and proposed systems to be constructed by local entities.

- In response to the drought of the mid-1960's, the State conducted a Statewide Reconnaissance Study which identified a program of needed action in water resources development.

- River basin plans have been completed on all rivers with the exception of the Hudson, and a Level B study is being conducted in that basin with completion anticipated in April 1979.

- Basin water quality, Section 303(e) plans, which govern decisions for sewage construction grants, have been completed for all basins.

- Section 208 planning, under the Water Pollution Control Amendments of 1972, is well advanced, and our newly drafted State/EPA Agreement has been developed to ensure the orderly integration of water quality management planning and implementation activities.

- New York State is a signatory party to the only two Federal-Interstate Compacts in the Delaware River Basin and the Susquehanna River

Basin Commissions which have regulatory functions for water and land resource management and participates in three river basin planning commissions: the New England River Basins, Great Lakes Basin, and the Ohio River Basin.

There are, of course, many other planning and program management activities at all levels of government and in the private sector which are incorporated into the overall water resources management scheme.

Lest this historical rendition leave you with the impression that all is well with water resources management in New York State, let me assure you that this is not the case. Our basic problems may be encapsulated in a few brief statements:

- Water quality degradation from a multitude of sources
- Aging water supply systems in desperate need of costly rehabilitation and construction
- Ever-increasing per capita demand for increased supply development
- Increasing functional conflict over allocation of available supplies.

And there are very difficult legal, institutional, and programmatic barriers which must be addressed before the people of New York can begin to solve these basic problems:

- Poor meshing of water quality and water quantity planning and programs with each other and with land use planning
- Inability to obtain local financing and lack of a Federal program for support of urban water supply system rehabilitation and construction
- Too many water supply agencies
- Little program consistency among Federal agencies
- Historical dependence on new supply development to the exclusion of demand reduction
- Remaining emphasis at all levels of government on structural solutions to problems and insufficient funding and consideration for non-structural approaches
- Insufficient public information and participation with a resultant overall lack of interest in water resources planning and development
- Lack of consistent support for planning which results in the dismantling of planning staffs with each wave of budget-cutting

- Difficulty in bringing any reasonable semblance of coordination to the multitude of overlapping and sometimes conflicting programs.

New York has a long tradition of resource protection and management, but we still face very serious water problems which are shared by States across the country and which will require new, flexible water policies and programs at all levels of government, as well as a better understanding by the people. There must be a willingness, however, to invest in and support conservation as a companion to this development. Because our problems are predominantly urban in nature, the following discussions of water quality and water supply should be viewed from the standpoint of an urban contribution to a national water policy and programmatic implementation.

WATER QUALITY

The water quality management problems which most commonly contribute to serious water pollution and affect the largest percentage of the State's population occur in urban areas. The sources of these problems are known to all of us: municipal discharges, industrial discharges, residual wastes, combined sewer overflows, urban storm runoff, and hydraulic-hydrologic modifications. The major categories of pollutants are also well known: organic oxygen-demanding materials, infectious agents, nutrients, thermal discharges, sediments, and minerals.

Recently we have all learned about the very serious threat to the environment and to public health caused by toxic materials and other hazardous substances. The lower Mississippi River, the Hudson River, Lake Michigan, Lake Ontario, and the Chesapeake Bay are but five of the vitally important national bodies of water which are seriously affected by toxic materials. Because all of them are used either as sources of water supply or growing areas for food products, it is crucial that our water quality management link closely with our use and development of water supplies.

The problem of urban runoff is particularly critical in some of our older, larger cities which have combined sewer systems. This is a major unmet water quality need which has the potential for adversely affecting the use of our water for drinking, agriculture, and food production.

Specific examples of water quality management problems can be cited by all of us; New York State certainly has its share. Major shellfishing areas off Long Island were closed during 1977 due to coliform levels resulting from discharge of inadequately treated sewage effluent, urban storm runoff, combined sewer overflows, and vessel waste discharges, much of which emanates from the New York City area. The New York Bight, once an abundant near-shore fishing ground of some 3,000 square miles, has been described as a "dead sea" in some parts as a result of the effects of ocean dumping and other pollution carried into it from New York Harbor and tributary waters. Toxic problems in the Hudson River (PCB's) and in Lake Ontario (Mirex) have restricted fishing in those areas. Beaches on the south shore of Long Island were closed for more than a week during 1976 due to an influx of floating solids and related public health problems. Beaches near Rochester are closed permanently because of the high coliform levels brought by combined sewer overflows and urban storm runoff.

Water quality planning and programming is well advanced in New York State and gives promise of payoff if all activities can be coordinated into a whole. A specific water management context is now available for linking together the challenges for water quality and water quantity. Used first in New York State, it is an agreement between our Department of Environmental Conservation and the Regional Administrator of the United States Environmental Protection Agency (State/EPA Agreement) to provide the context, program, and priorities for our State water management.

This State/EPA Agreement outlines strategies covering the next 5-year period for meeting public goals for water management in New York State. It sets priorities and milestones for accomplishment of management objectives. It reflects a second generation of strategies to carry forward the State's program. The Agreement reflects new emphasis on:

- Water management relating water supply and water quality
- A broader approach to water resource management through greater attention to such activities as ground water management and flow regulation
- New emphasis on protection of public water supplies
- Water conservation and reuse
- Recognition that the State Department of Environmental Conservation is in a period of extensive program development for newer water quality concerns related to toxic residual wastes, nonpoint sources, multiple use, best management practices, and other non-structural approaches
- Greater attention to coordination with environmental resource protection.

Lastly, ground water is our underground reservoir. Not only must we keep the level of ground water high, but we must also prevent its pollution. At the present time, growth in land use activities such as deep well injection of industrial wastes and pooling of contaminated water discharges are fouling the watersheds and aquifers which are now used for public water supplies. Public health hazards exist, and the remedies for them are often unknown or unavailable because of the magnitude of the problem and cost of the solutions. Pending legislation would provide the data base and management tools necessary for New York to better manage its ground water resources and bring about their integration with the surface waters of the State. And, of course, we view the major challenge of an urban water policy as the linking together of water quality and water supply into a single comprehensive program.

WATER SUPPLY

Historically, water supply has been the responsibility of local government. In recent years, development of new supply, treatment, transmission, and rehabilitation of aging systems has become increasingly expensive and difficult to attain. The supplies readily obtainable within the jurisdiction of communities, particularly cities, have, for the most part, been developed. New sources are at increasingly greater distances from the users, are across jurisdictional boundaries, and require extensive transmission facilities and sophisticated treatment.

I would like to suggest that the time has come when the national interest is best served by maintaining and enhancing the viability of our urban centers through a Federal/State/local comprehensive effort to assure the provision of sufficient dependable supplies of quality water.

Such an effort will be expensive, and we should look at the question of equity before discussing program. While the population of the United States has expanded by approximately 6.5 percent since 1970, New York has lost at least 300,000 residents. This loss is fairly typical of the urban Northeast and has occurred while some areas of the country were enjoying unprecedented population growth and accompanying economic development gains. While New York received only an average of one to two percent of the Federal Civic Works budget, it has about 8.5 percent of the national population, a corresponding share of needs, and, to cite 1976 as an example, had a $7 billion deficit in its overall balance of payments with the Federal government. While our urban infrastructures deteriorate, an excess of $7 billion per year is drained from the State through a system of detrimental Federal aid formulas.

To emphasize this situation, which is rather typical of the older urban States, Senator Proxmire entered into the October 5, 1978, Congressional Record a list of all States, their shares of water project construction funds, and their Federal tax contributions. With a few exceptions, the States which have failed to share in the national expansion have received practically no Federal expenditures for water projects but have provided a lion's share of the revenue to support those projects.

Now a look at New York's urban areas and their water supply problems.

The State has ten major urban areas (SMSA's) which, in 1970, contained 89 percent of the population. The largest is New York City with a population of approximately 8 million; the smallest is Poughkeepsie with a population of 32,000.

The water resources economically and practically available to meet future metropolitan area needs are limited. New York City has had to reach out into the Catskill mountains, as far as 120 miles away, for reservoir sites to store "pure" mountain water that is transported to the city through a complicated reservoir-aqueduct system. Similarly, the Syracuse area is supplied with water from Lake Ontario about 40 miles away. These distances are not great when compared to the viaducts of California, but they show that even in the "water rich" East, water supply is a very serious issue.

In New York State, there are 17 water supply systems serving urban areas with populations ranging from 50,000 to 100,000. Twenty-one systems serve populations of 100,000 to 1,000,000. The New York City system is by far the largest, serving a population of 8,000,000. In total, there are 737 public water supply systems in New York State serving a population of 15,000,000 people.

The comprehensive county public water supply studies referred to earlier indicate that more than 76 percent of existing local water systems are in need of one or more major improvements. These improvements are in the category of source of supply, transmission, treatment, pumping, storage, and distribution facilities. The estimated cost of these improvements is on the order of $500 million, not including New York City.

The major water supply need in the State is in Southeastern New York, an area encompassing eight counties and the City of New York. Previous estimates suggest that there could be as much as a 300 to 400 million-gallon-per-day shortfall in this region's water supply by the year 2000 if a drought were to occur as serious as that of the mid-1960's. Much more importantly, however, there must be a major increase in the transmission system to provide adequate delivery capacity to the mid-New York City area.

Estimates for a total water supply project for the region run as high as $3.8 billion. Absolutely essential improvements to the transmission system will require an estimated $2.1 billion. This problem was delineated during the Northeastern Water Supply Study recently concluded by the U.S. Army Corps of Engineers. It may be expected that similar urban water supply needs will be definitively established in other areas of the country as well when similar studies are completed.

In order to begin to address the critical needs and relationships of urban water supply, the following elements of policy and program must receive the immediate attention of policymakers at all levels of government in both the executive and the legislative branches.

At the Federal level we need:

1. A Support for Comprehensive Water Resources Planning and Management

   - Consistency among Federal agencies with adopted water resources plans

   - Continuity of support for management programs; we ask for the $25 million funding as requested by the President for support of state activities in this area

   - Equitable treatment of all alternative solutions, structural and non-structural

- A uniform criteria for planning and evaluating all Federal projects

- Expanded water research tied closely to the planning and management concerns of the States.

2. A Water Conservation Program

In order to bring about the necessary balance between development and wise use, we ask for immediate implementation of the President's water conservation proposals with broad application as an ethic and with specific program actions in all functional areas of water use.

3. Funding Assistance for Water Supply Facilities

Referring back to the specific program needs of urban America, I would like to present for your consideration the framework for a Federal program of urban water assistance with the stated goal of assisting urban areas to rehabilitate water supply distribution systems in order to assure reliable water supplies which are adequate in quantity, pressure, and quality to meet the needs of users on an economical basis for domestic, municipal, industrial, and other public purposes.

- Purpose: to upgrade the existing water supply distribution networks for the Standard Metropolitan Statistical Areas

- Inclusions: authorizations for construction of primary and secondary distribution systems, including pumping stations

- Eligibility

  a) water conservation program in place

  b) demonstrated need

  c) inability to meet costs

  d) to meet current requirements--not to meet growth

- Scope

  a) replacement of existing lines

  b) laying new lines as backup and for reliability where replacement is not the most economical alternative

- Conservation

  a) program leading towards universal metering

  b) water-saving fixtures

c) pricing policy

d) leakage control and comprehensive maintenance program

e) emergency use plan

f) educational program

- Cost Sharing

  a) 75 percent Federal, 25 percent local

  b) long-term Federal loans for local share.

We would view such a program as offering one-shot Federal assistance to help recipient cities rehabilitate their water supply systems as a part of the urban infrastructure strengthening needed to guarantee the very viability of those cities. In order for such a program to operate in this manner, it is essential that the conservation and management elements be mandated as a precondition of participation.

We might also want to consider some form of joint dedication of revenue from water supply, sewage disposal, and possibly solid waste disposal to the future maintenance and development of these functions so critical to urban life.

In New York State we are pursuing these actions:

1. Expanded Water Management Legislation

- A requirement that the Department of Environmental Conservation make an annual report to the Governor and the legislature on the status of water use and development in the State. The intent is to supply current information on which responsive leadership and legislative actions can be based. This requirement also provides a means of gathering heretofore unavailable data.

- A statewide well-drilling permit program to provide a management tool and data gathering system for a more extensive consideration of the ground waters of the State, particularly their relationship to surface waters.

- A comprehensive permit system for all withdrawal, storage, or use of significant amounts of water, including a priority for allocation in times of shortage. In recognition of the crucial nature of the water resources of the State to the health, safety, and welfare of the people as well as to the development of industry and commerce, implementation of this piece of legislation would assure wise use and prevent unnecessary depletion of water resources.

- A requirement that all purveyors of water develop and file with the State water shortage contingency plans. Such plans will assist in the mitigation of negative effects on the health, safety, and welfare of the public during shortages, assure that a plan of action will be implementable, and minimize negative impact on economic stability during critical periods. Such plans are also important to the development of the acceptable risk factors in a total water management strategy.

2. Water Management Program Expansion

The State of New York intends to provide the leadership and program management necessary to address the major problems of water resources management, including implementation of new State legislation and the programs called for under the President's water policy.

3. Water Conservation Legislation

- A statewide requirement that only water-saving fixtures be used. Although some years will be required for maximum savings to accrue, this action offers savings of from 26 to 56 gallons per capita per day (an estimated annual Statewide savings in the year 2000 of 110 billion gallons).

- A requirement that all new construction and major renovation be metered. As applied to New York City where only about 20 percent of the volume is metered, it has been estimated that an eventual savings of from 100 to 200 mgd could be realized.

- All public suppliers of water would be required to conduct a program of leakage control including monitoring, prevention, and repair of all significant leakage.

In addition to these basic measures now being considered, additional water conservation measures, which may be contemplated by the State in the future, include increased recycling of industrial waters and a pricing policy supportive of conservation, particularly during high-use times. In addition, the Department of Environmental Conservation is taking aggressive measures to insure that water conservation is factored into the design of all sewage treatment plants.

It is now up to State and local governments--in partnership with the private sector-to build water conservation programs suitable to their areas and levels of responsibility. We must affect positively and strongly the Federal government's program for implementing water conservation and the known means to apply water conservation, to mold it into a format suitable for use, and to broaden the knowledge of us all. Strong support for the National Governors' Association's recommended conservation principle will assist in obtaining a broadened Federal interest in fiscal and program support for conservation.

But, fundamentally it is up to the States. We must build our programs for water conservation and management.

New York is moving to meet the current challenges of urban water supply as a major component of an overall comprehensive water resources program. At the same time, we recognize that other States and regions will have differing combinations of priorities, and we firmly believe that the new national partnership developing among the parties at interest, at all levels of government and in the private sector, can bring regional and program equity to the management of this critical resource.

Water and Sewer
Conservation-Oriented Rate Structure

Robert S. McGarry
General Manager
Washington Suburban Sanitary Commission

In Washington these days, there is very little agreement but it does appear that almost everyone agrees that the Nation's capital region faces a potentially serious water supply problem. There is no consensus on how serious the problem is, but a typical projection for the Washington metropolitan area is shown in Table 1.

For many reasons beyond the scope of this paper, a regional solution to this serious problem acceptable to the Federal, State and local governments has not been developed, despite numerous expensive Federal and local studies of the problem since the 1966 drought.

Faced with this impending water shortage for which there is no regional solution, the Washington Suburban Sanitary Commission (WSSC) -- one of the three water supply agencies serving the Washington, D.C. region -- has developed a water conservation program and interim local supply plan based on conservation and drought management.

WSSC serves about half of the regional population, 1.2 million, living in Prince George's and Montgomery Counties, Maryland. Figure 1 summarizes the Commission's services.

The Commission is unique in that it is an independent regional agency established and governed by Maryland State laws. While working very closely with the county governments, the authority and responsibility to plan, finance through bond sales, construct, and operate the necessary facilities to meet bicounty needs is clearly WSSC's. In addition, WSSC has full authority to set water and sewer rates to insure revenue to meet operating and debt expenses. We also establish and enforce the plumbing codes for the bicounty region. These strong regional authorities were very valuable in the development of our conservation program.

WSSC developed the water conservation program for three reasons: First, we had no choice; second, to save capital and operation expenses; and third, our "public" wants such a program.

As indicated previously, the demand for water will exceed the supply from the Potomac between 1980 and 2000 if per capita consumption and the

TABLE 1. WASHINGTON, D.C. METROPOLITAN REGION:
POTOMAC RIVER SUPPLY VS. DEMAND

Year	Projected population (millions)	Per capita consumption (gal/day)	Potomac River	
			Demand (mgd)	Flow (mgd)
1980	2.9	134	415	535
2000	3.7	141	635	535
2020	5.2	142	855	535

Water and Sewer Service for Prince George's
and Montgomery County, Maryland

1,000	Square miles service area
1.2	Million population (250,000 customers)
130	Million gallons/day average - 210 mgd peak
2	Water treatment plants
3,416	Miles of water distribution lines
9	Sewage treatment plants
3,356	Miles of sewage collection lines

Figure 1. Washington Suburban Sanitary Commission

population increase as projected. We must conserve. If per capita consumption can be held constant -- or better, reduced -- reasonable population growth can be supported for a longer period, thereby buying time for a regional solution. Since population control is probably not feasible in the Washington region, an increase in dependable water supply must be developed and conservation only buys time. The Washington, D.C. region also has a shortage of sewer capacity, and water conservation is essential to avoid a building moratorium and allow reasonable development while additional sewer treatment facilities are being planned and built. But perhaps the most important reason for water conservation is the fact that the public, the regulators, and the legislators have made it abundantly clear that any regional solution will be blocked and eventually disapproved unless our use of water is conservative. One of the major reasons previous regional water supply plans have not been acceptable is the impact -- environmental fiscal, social, and political -- of reservoirs large enough to insure unlimited water use. Planning for unrestricted use is no longer acceptable to our public and our regulators.

Like all other utilities, WSSC is seriously concerned by increasing capital and operating expenses. Through reduced per capita consumption we expect to avoid some very expensive expansion programs and lower operating expenses, especially in our sewage treatment plants.

The third reason for conservation, because our public wants such a program, may or may not be unique to WSSC. Every indicator of public opinion tells us that our customers strongly support our efforts. The "conservation ethic" is strong in our jurisdiction and has been extremely helpful in achieving our goals.

WSSC's conservation plan has three elements:

- publicity and education
- plumbing code revisions
- conservation-oriented rate structure.

WSSC's publicity and education program is not unique. However, it is sincere, innovative, and absolutely relentless. Conservation is a way of life for all our staff and our customers.

Because of our authority for the plumbing codes in the bicounty region, it was relatively easy to change the code to require 3-1/2 gallon toilets, 3-1/2 gallon-per-minute (gpm) shower flow controls, and pressure-reducing valves where the water pressure is greater than 60 pounds per square inch (psi) for all new construction and renovation. Through our plumbing permit procedures and well-trained plumbing inspectors we have vigorously enforced the revised code. The changes have been accepted, and even endorsed, by plumbers and builders. There have been virtually no complaints and no problems. Our experience suggests that there is absolutely no reason for any jurisdictions interested in conservation not to revise their plumbing codes as we have.

In January 1978 WSSC initiated the last element of our conservation program, an increasing water and sewer rate schedule.

The rate-setting process at the WSSC is fairly basic. Rates are determined by the Commission in order to fund the expenditures approved by the two County Councils of the area we serve. The expenses that were approved in the fiscal year 1978 budget were $35,232,000 for water operating and $44,215,000 for the sewer operating fund. Based on an estimated consumption of approximately 42 billion gallons of water, a water rate was set at 70 cents per thousand gallons and a sewer rate of 98 cents per thousand gallons based on water billing. In addition to these basic charges, the WSSC levied a summer surcharge of 20 percent of the basic water rate for the summer period of June, July, August, and September. A service charge for each metered account was also assessed dependent upon size of the meter. Miscellaneous investment revenues and service charges produced the balance. In the sanitary district, all water consumption is metered. Meters are read for our single-family residential customers on a quarterly basis and our larger accounts are read monthly. Our monthly accounts, commonly referred to as business accounts, include everything that is not a single-family residence. This includes office buildings government, multi-family units, industry, and other commercial operations. Table 2 is a summary of the rates that were in effect prior to January 1978.

The new rate structure was the result of a two-year study. The keystone of the study effort was a Citizen's Advisory Committee on WSSC Rates and Charges, which included citizens representing a wide variety of interests and organizations from Prince George's and Montgomery Counties. The members were selected by the Commissioners from nominations received from business and civic groups in both counties, as well as individual, independent citizens who applied to serve on the advisory unit. The keystones of the Citizen's Advisory Committee's recommendations were:

- customers causing increased demand should be required to pay for extra capacity required.

- the price structure should encourage all customers to conserve.

This group, as well as the WSSC staff, had considered a wide variety of proposals including:

a. spatial differentiation of pricing
b. seasonal pricing
c. increasing block structure
d. decreasing block structure
e. average variable cost pricing
f. flat rate sewer service charge
g. summer surcharge system
h. flat rate charges
i. excess-use charges.

TABLE 2. WSSC 1978 RATES

Rate	Billing
Water	
$0.70/1,000 gal.	October thru June
$0.84/1,000 gal.	July thru September (summer surcharge)
Sewer	
$0.98/1,000 gal.	All year
Service charge	
$2.00 or $3.00 (single-family residential)	Quarterly
$1.00 to $75.00 (business)	Monthly

The final recommendation of this Committee was to adopt an increasing rate structure for water and sewer and to eliminate the summer charge and the meter service charge. The Committee deferred to WSSC for commercial, government, and industrial users.

In translating the Committee's recommendation into a rate proposal, a review of key customer information is essential. For example, the WSSC has a total of 230,000 accounts of which 91 percent, or 210,700, are single-family residential customers. The single-family consumption, however, represents only 48 percent of the total consumed water within the sanitary district. Table 3 reflects the proposed rate structure and impact on the number of accounts. It should be noted that the largest number of accounts are in the 201 to 350 average-gallons-per-day range. A translation of the rate proposal into the impact on single-family accounts can be seen in Table 4. From the rate proposal developed in response to the citizen's group, the smaller consumers using up to 100 gallons per day (gpd) would have their rates cut almost in half. Mid-range customers, up to 350 gpd, would have bills equivalent to what was then in effect. The larger consumers, approximately 28 percent of total accounts, would have bills gradually increasing. Year-round conservation is important. A typical consumer using 200 gpd for the year would pay approximately $23 per quarter. However, if during the heavy demand period this account would double its consumption, the water bill would triple to approximately $73.

While it is impossible to precisely measure public feeling, we sensed strong support for our proposals. However, throughout the study of increasing rates (versus constant rates), two special impacts were known, discussed openly, and carefully considered: the impact of such a rate structure on large commercial users of water, and the impact on large families.

It is true that those industries which use large amounts of water (1,000 gpd or more) for business purposes will pay at the highest rates. It has been argued that these demands are for essential use and not due to wasted water or non-essential summer demand. In many cases, it is not possible for these large water users to reduce their average daily consumption below 1,000 gpd to take advantage of decreasing rates.

We were aware of this impact and studied several alternatives for commercial accounts; but, for several important reasons, we did not adopt any commercial alternative.

We feel that the larger users, especially those with summer peaks, should pay a higher rate to offset capital costs for expanded water and sewer facilities. This principle applies to all -- commercial, government, and private consumers.

WSSC operates under a code enacted by the Maryland General Assembly that requires a uniform water and sewer rate schedule for all customers. A special rate (s) for any class (es) of customers (commercial, large families, public institutions, etc.) would not conform to the code. WSSC may support

TABLE 3. PROPOSED SINGLE-FAMILY RESIDENTIAL RATES

Metered consumption (gal.)	Average daily consumption (gal.)	Number of accounts	Proposed rates (per gal.)	
			Water	Sewer
0-9,000	0-100	21,500	$0.40	$0.53
9,001-18,000	101-200	56,500	0.55	0.74
18,001-31,500	201-350	72,500	0.79	1.00
31,501-45,000	351-500	31,500	0.90	1.14
45,001-90,000	501-1,000	23,700	0.95	1.20
90,001 and up	1,001 and up	5,000	1.00	1.26

TABLE 4. IMPACT OF RATES ON SINGLE-FAMILY USERS

Average daily consumption (gal.)	Number of accounts		Sample bill present rates per quarter	Sample bill proposed rates per quarter	Quarterly consumption (gal.)
	No.	%			
0-100	21,500	10	$ 17.43	$ 8.37	9,000
101-200	56,000	27	32.87	23.22	18,000
201-350	72,500	35	57.02	56.38	31,500
351-500	31,500	15	80.18	91.80	45,000
501-1,000	23,700	11	157.35	193.50	90,000
over 1,000	5,000	2	257.25	339.00	150,000
TOTAL	210,700	100%			

a change in the code to give us the flexibility to modify the rate structure, if experience and further study identify alternatives that will accomplish the same objectives of conservation and equitable cost distribution.

We have strong evidence that the previous uniform rate did not encourage serious conservation by some of our commercial customers, whereas the new rates should cause commercial managers to initiate conservation programs. Also, many of our commercial customers are small consumers of water, and they will benefit from conservation practices by lower bills. Special rates for all commercial accounts could penalize the small commercial customers.

In examining the problems with the application of a single increasing rate proposal on our business customers, one problem was solved; specifically, that of multi-family units or the almost 2,400 accounts that comprise garden and high-rise apartments in suburban Maryland. These 2,400 accounts represent a significant portion of the water consumption (almost 30 percent) in our service area. In order to place these family units on a comparable basis with single-family units, a system was devised to add a further element to the billing formula which would provide a per-unit bill. Each account was requested to certify the number of units served in the particular complex. This figure was identified in our computer billing and thus, before determining the rate schedule to use, the monthly consumption was divided by the number of units to determine and bill on a per-unit basis. Table 5 indicates actual apartment complexes and demonstrates that the same conservation goal can be achieved. Note that the conservative apartment building using approximately 100 gallons gpd per unit is rewarded by a 30 percent reduction in its per-unit bill (Apartment Number 2). Whereas Apartment Number 3, the more wasteful customer, has its bill increased by almost 12 percent. The average, well-managed apartment complex uses about 200 gpd per unit, but there are many who use over 400 gpd per unit. The new rate structure will severely penalize wasteful patterns of consumption by the apartment complexes with these high consumptions, and they will either improve their management or pay for the excessive wasteful demands on our system.

The other major problem was large families. While we have heard a great deal of criticism from the accounts with families of six or more, the majority of customers seem to feel, including the unanimous agreement among the Citizen's Advisory Committee (some with larger families) that with minimal effort these families can reduce consumption to where they can take advantage of the lower rates. From a citizen's perspective, single-family accounts, regardless of size, who use water excessively for lawn watering, filling swimming pools, and so forth, should pay for these luxuries. Our experience has been that many of those who have complained are suburban families with several teenagers or young adults living in sizable homes with two to three bathrooms, numerous cars, and large lawns, who in fact are not practicing conservation efforts.

TABLE 5. EXAMPLES OF UNIT BILLING FOR MULTI-FAMILY ACCOUNT

Account	Number of units	Current monthly bill per unit	Daily consumption (gal./unit)	Alternate monthly unit bill per unit
Apt. #1	525	$19.68	365	$22.32
Apt. #2	8	5.79	104	4.04
Apt. #3	244	25.06	472	27.93
Apt. #4	66	19.83	366	21.63
Apt. #5	272	10.34	187	7.23
Apt. #6	516	15.73	228	15.40

However, to test the schedule, the WSSC did study the impact of the proposed rate structure on low and moderate income families of varying size. In cooperation with Montgomery County, a small sample of households with variations of family size and income were include. Fifty-four percent of the sample had 3 to 5 family members and 23 percent had fewer and 23 percent had more members. The results of the survey show that there was no correlation between large families and increased bills. Three large families (six or more members) would have received an increased bill under the proposed rate structure and two large families would have received a decreased bill. For one family of eleven, the new rate structure would result in a six percent decrease over five billing periods. It was concluded that the proposed rate structure would have a generally beneficial impact on most of the sampled families, and with increasededucation, many of the others could be helped to lower their water consumption and resultant bills.

Before acting on the new rate proposal, WSSC made an elaborate effort to obtain the public's views. Scheduled workshops, 10,000 direct mail questionnaries, speeches, meetings, press conferences, and informal meetings with community groups were held together with review by both County Councils. The views of all "publics" were carefully considered; on November 16, 1977, the Commission adopted the new conservation-oriented water and sewer customer rate schedule effective January 1, 1978. Believed to be the first rate plan of its kind ever implemented by a major American water utility, the structure (with 100 steps in 10-gallon increments) used the basic proposal that the level of charges be determined by the customer's average daily consumption (ADC) during each billing period.

The range of rates on the new schedule were set at $0.36 to $1.05 per 1,000 gallons of water consumption and $0.45 to $1.31 per 1,000 gallons of sewer use. The schedule started at a base ADC of 10 gpd with the lowest water and sewer rates and moved up incrementally to a top ADC threshold at 1,000 gallons or more, with the highest water and sewer rates applied to total consumption by the customer unit. Concurrently, the WSSC phased out the 20 percent summer surcharge and annual service charge. The new customer rates were designed to produce the required revenue to support the Commission's budget.

To assist the customers in understanding a very significant change in our billing structure, our new rates were not applied until the first bill received wholly within the calendar year 1978. Thus, our experience with the impact is based upon commercial accounts with billings beginning in February and the majority of residential accounts not receiving the impact until the second quarter in 1978. It was anticipated that, along with the other water conservation efforts that the Commission has practiced over the years, and with rate structure and continued publicity, that consumption for the fiscal year ending June 30, 1978, would be reduced by five percent per year. This first anticipated measurement did come true. Water consumption was down by approximately five percent from fiscal year 1977. Since the revenue loss was anticipated in setting the multi-step rate structure, the revenue for the same period was identical to that we budgeted within one-tenth of one percent.

With the institution of the new structure, a continuing analysis of the impact on consumption has been underway. Based on data through June, 1978, several interesting points can be made. First, commercial and governmental accounts have shown little change in consumption patterns, with a decline of only 0.03 percent, whereas residential customers have shown a 13.8 percent drop. This averages to an 8 percent decrease for the June, 1978 quarter compared to 1977 consumption.

Usage for the large commercial accounts (those using more than 20,000 gpd) was virtually the same for the two periods, 186,248,000 gpd versus 186,416,000 gpd. There have been isolated cases where large commercial accounts have significantly changed their consumption, such as a film processing firm which reduced its account by 35 percent, but these have been rather rare instances. As noted, the major consumption change has been in our single-family residential accounts. Table 6 shows the distribution of accounts based on average daily consumption ranges for the June, 1977 quarter as opposed to the distribution for June, 1978.

The overall reduction in consumption in excess of 13 percent is borne out by the fact that a major downward shift has occurred in each of the single-family residential ADC classifications. Statistical analysis of the consumption pattern for the WSSC generally recognizes that the peak demand for water is caused principally by residential customers. Since this is the case, it is hoped that the rate structure not only will work from an overall conservation standpoint, but will have a material impact on the peak demands on the system.

Based on the limited time period which has been analyzed, the conservation-oriented rate structure adopted by the WSSC has had an impact on our residential customers. The original objectives, namely a reduction in both the average daily consumption and the peak consumption and secondly, passing on to those consumers with large average daily demands and larger peak demands a more appropriate share of the capital and operating cost associated with the higher demands, will be met if these patterns are sustained.

The experience for commercial and government accounts has been disappointing and without changes will just mean higher prices and taxes passes on to the individual consumers. We will continue to monitor and emphasize this concern. Overall, the Commission will maintain its full commitment to policies which encourage customer water conservation and waste reduction, believing that sustained demand reduction is essential to the efficient use of existing and projected water supply and wastewater facilities.

TABLE 6. SINGLE-FAMILY RESIDENTIAL CONSUMPTION JUNE QUARTER, 1977 AND 1978

Average daily consumption (gal.)	Number of accounts 1977	Number of accounts 1978	Percent change
0-100	20,821	25,889	+ 24.3
101-200	54,577	64,213	+ 17.7
201-350	70,483	69,136	- 1.9
351-500	30,989	24,758	-20.1
501-1,000	23,205	17,334	-25.1
1,001 and up	5,097	3,711	-27.1
TOTAL	205,172	205,041	

TOTAL GALLONS BILLED: 5,235,090,000

Analysis of Participation
National Conference on Water Conservation and Municipal Wastewater Flow Reduction

Willis E. Sibley
Cleveland State University

A prime objective in the organization and solicitation of participants in the National Conference was to encourage persons representing different aspects of and approaches to water conservation and wastewater flows to gather to discuss common problems and concerns. The perspectives of consulting engineers and environmentalists frequently are different, for example. In the absence of opportunities to meet, awareness of others' perspectives and knowledge may be lacking, to the loss of all concerned.

The accompanying chart (Table 1) suggests that the objective was substantially achieved. All levels of government were well represented, with local-level governments having the highest participation rate--which ought to be expected, given the number of such units dealing with water problems. The Federal government was represented well, again as would be expected, both because it is the prime funder of wastewater projects and because it establishes national policy in such matters.

Citizen action groups tend to be the more "visible" representatives of the body politic, as citizens try to interact with and influence Federal, State, and local policies concerning conservation, water, and wastewater matters. They were well represented. Many of these participants took pains after the conference to note their pleasure and exhilaration at meeting face-to-face with government representatives and consulting engineers, whom they often find elusive targets in their attempts to influence policy and action.

It is pleasant to note the number of consulting engineering representatives who attended. They critically affect the implementing of Federal, State, and local water/wastewater policy since they tend to dominate the field of facility design and execution. The need to acquaint them with citizens' needs and views is clear as well as pertinent to the growing emphasis on citizen participation.

Trade and commercial interests probably have more influence on matters of concern to the conference than their attendance numbers represent. Through the activities of such groups as the Plumbing Manufacturers Institute, they are making significant advances in designing, building, and promoting water-saving fixtures and equipment for all levels of water equipment construction and use, from residential to commercial installations. In a future conference, more successful and intensive efforts to reach this group probably are warranted and desirable.

Regional groups involved with public planning processes and programs also were less than optimally represented in this conference, since they presumably might be vital links to other forms of political/geographical units with water concerns.

On the whole, however, the effort to bring together persons who will influence policy and who have divergent views seems to have succeeded. The fact that more than 450 persons still attended the final session of the conference, from a total of somewhat more than 500 at the opening session early the previous day, is another measure of success, probably reflecting both the quality of the program and the quality of interchange which accompanied the formal program.

TABLE 1. ANALYSIS OF PARTICIPATION IN NATIONAL CONFERENCE ON WATER CONSERVATION AND MUNICIPAL WASTEWATER FLOW REDUCTION, CHICAGO, ILLINOIS-NOVEMBER 28-29, 1978

Type of Participant	Number of Individuals[a]	Percentage of Registrants[b]
GOVERNMENT		
Local	59	17.0
County	11	3.2
State	28	8.1
Federal--all EPA offices	50	14.4
Federal--non-EPA	26	7.5
Gov't. associations	1	<1.0
TOTAL GOVERNMENT	175	<51.2
CITIZEN ACTION		
Environmental groups	39	11.2
Groups not exclusively environmental	14	4.0
TOTAL CITIZEN ACTION	53	15.2
ENGINEERING		
Engineering consulting	46	13.2
Engineering associations	2	<1.0
TOTAL ENGINEERING	48	<14.2
RESEARCH		
University personnel	23	6.6
Foundations, non-profit	8	2.3
TOTAL RESEARCH	31	8.9
TRADE, COMMERCIAL		
Trade & manufacturing representatives	16	4.6
TOTAL TRADE, COMMERCIAL	16	4.6
PLANNING		
Regional planning groups	11	3.2
Planning associations	1	<1.0
TOTAL PLANNING	12	<4.2
OTHER		
Consultant, non-engineering	1	<1.0
Media/publishing	6	1.7
Persons with unknown affiliations	2	<1.0
Union representatives	3	<1.0
TOTAL OTHER	12	<4.7
GRAND TOTAL	347	100.0+

Notes: a. The total of 347 represents only those with fully completed registration data. The meeting opnened with 500+ participants and ended with 450+ persons.

b. Totals more than 100 percent because of rounding and "less-than-one-percent" categories.

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